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Elmira's Source of Power

TURBINE EQUIPMENT THROUGHOUT; COMPLETE COAL AND ASH HANDLING EQUIPMENT; HIGH BOILER ROOM EFFICIENCY; AUTOMATIC CONTINUOUS RECORDS

IN THE DEVELOPMENT of central stations, we have seen, even during the past decade, many changes not only in types of machinery used, but in methods of handling coal and ashes, transmitting and controlling steam, additional accessories, including instruments, etc. All of these changes have had in view 2 objects—increased safety to workmen and plant, and economy in producing electric energy.

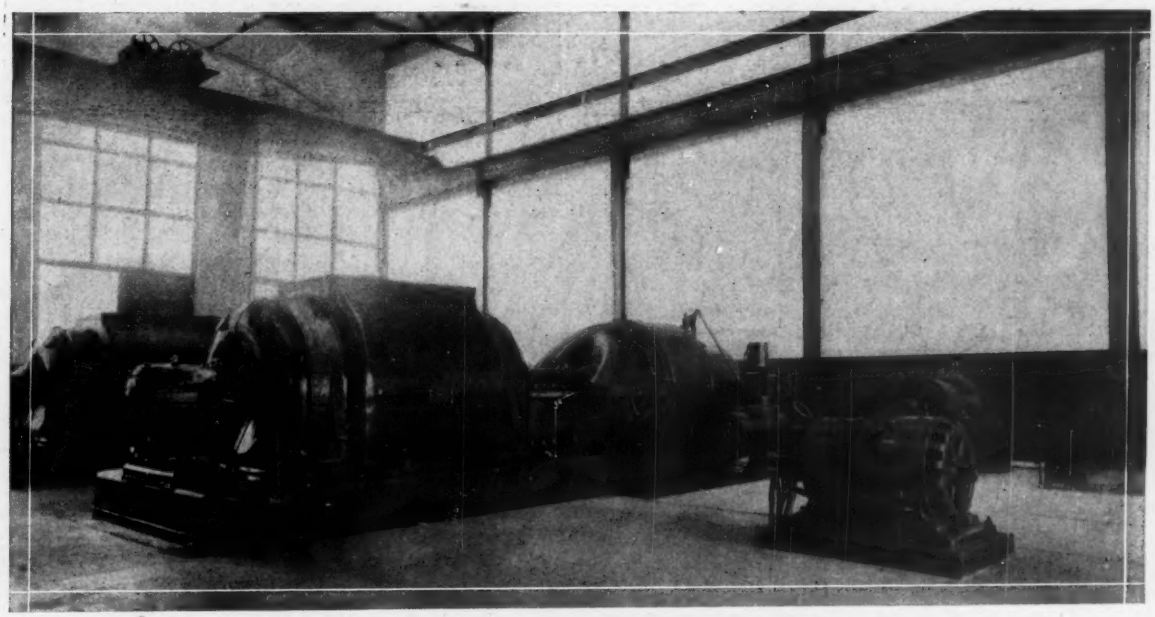


FIG. 1. TURBINES AND EXCITERS; ELMIRA POWER PLANT

To one who has kept abreast of the times, knows when machinery has passed the experimental stage, and its relative value in its field, there is great pleasure in witnessing the operation of all these modern machines and appliances in everyday work. Such is the equipment of the Elmira Water, Light & Railroad Co.'s plant in Elmira, N. Y. Everything in the plant is of the latest, most successful design which has been thoroughly tried out and nothing of real value in the operation of the plant has been omitted.

Coal used in the plant is Shawmut slack, though provision is also made for handling mine run. It is delivered on a spur of the D. L. & W. R. R., which runs through the yard and beside the power house on trestles which will accommodate 6 cars. There is storage space in the yard beside the track for 10,000 to 12,000 tons of coal which is delivered to the plant from storage by a grab bucket on a locomotive crane.

In ordinary operation, cars are brought to the plant and weighed on Howe scales, which stamp the weight on a ticket; without moving the car, the coal is dumped into a hopper just beneath, placed between the 2 sections

of the scale platform, the weight of the unloaded car is then taken, and the car may be removed.

Beneath the scales is a Meade-Morrison coal crusher which is used or not, according to the grade of coal delivered. From the crusher the coal is discharged into a skip hoist car of 1 ton capacity, which is drawn on an inclined track by a cable to the top of the boiler room where it dumps into a 2-ton distributing car. This runs on a track slightly inclined downward from the loading point so that when released, after loading, it runs by gravity until it is over that part of the bunker it is desired to fill, when it strikes a drag and trip, dumping the coal to a concrete bunker over the boiler furnaces. A counterweight and cable carry the car back to its loading position where it is held until loaded and released by the operator.

FIG. 2. REAR VIEW OF ELMIRA PLANT

Only half the boiler capacity of the plant has been installed, so that at present the capacity of the concrete bunker is about 1000 tons, which will be increased to about 2000 tons when the plant is completely equipped.

There are at present 4 750-hp. B. & W. boilers in the plant with provision made for 4 more of the same size. These are placed in 2 rows with a firing aisle between. Serving the boilers are Taylor underfeed stokers, placed so as to give a space of 10 ft. between the grate and the lower row of tubes. Steam is developed at 210 lb. pressure, with safety valves set at 225 lb., and superheated 125 deg., 2 of the boilers being supplied with B. & W. superheaters, the other 2 having Foster superheaters.

Aside from the standard equipment, these boilers are each provided with a G. E. steam flow meter, feed water regulator (2 S-C and 2 Copes), Blaisdall-Canady system of draft regulation, a Uehling CO_2 indicator, Westover combustion indicator, and an Ellison draft gage with connections to the various parts of the settings as follows: Under stoker, halfway between grates and tubes, to second pass, to boiler side of damper, and to stack side of damper.

The coal used has an average thermal value of 14,300 B.t.u. per pound and is discharged from the concrete bunkers to Howe hopper scales, one of which serves 2 boilers, being carried on rails to any desired position over the stokers. A record of the amount of coal fed to each boiler is kept by the fireman. As an additional check on the weight of coal, each stoker which has 8 retorts, has an electric contact maker which operates a stroke counter in the engineer's office; contact is made at each revolution of the stoker, which has been carefully calibrated, so that the reading of the stroke counter multiplied by the stoker constant gives closely the weight of coal used.

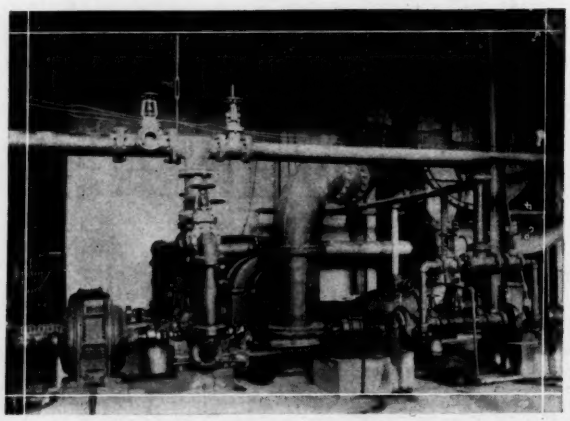


FIG. 3. CONDENSING APPARATUS OF TURBINES

From the scales the coal is discharged directly to the hoppers of the stokers through chutes. Driving each stoker is a 7½-hp. American Blower Co. engine. These, it may be noted, are the only reciprocating engines in the plant. The speed of the engines is automatically controlled by the quantity of air entering the furnace. The arrangement of the shafting and capacity of the engines is such that, in case it is desirable, one engine may be used to drive the 2 stokers in the setting.

Air is supplied to the furnaces under forced draft of 3 to 4 in. of water by Sirocco fans, one for each boiler, located in the basement and driven by 35-hp. G.E. motors.

In the plant are 2 Sturtevant economizers, each taking the gases from 2 boilers; the tube scrapers are run by 5-hp. motors. Each economizer is provided with a full set of Bristol recording thermometers giving feed water temperatures in and out, and gas temperatures entering and leaving.

Two smokestacks serve the plant, being designed to take care of 4 boilers each. The height of the stacks is 275 ft., and the inside diameter 11 ft. at top. They are

built up of reinforced concrete in 5-ft. sections, but lined with brick 187 ft. As a protection against lightning, 2 cables run to the top of each stack and are connected at the bottom to the intake and discharge water pipes to the river. An ornamental feature of the stacks is 3 1000-watt nitrogen lamps at the top of each stack, which shed considerable light on the surrounding neighborhood.

Ashes are dumped to reinforced concrete hoppers beneath the furnaces, where during time of cleaning fires they are wet down. From the hoppers they are discharged into Treadwell industrial cars which take them on tracks to the ash elevator at the rear of the boiler house, shown in Fig. 2. Here the cars are elevated and the ashes dumped into a storage bin with capacity sufficient to hold a car load. From the bin, the ashes go by gravity through a chute to a car on the side track.

Course of the Feed Water

The plant is located on the bank of the Chemung River, from which all water used about the plant is taken. The entrance to the intake line is provided with a trash rack and screen set in concrete, and from this line 2 De Laval centrifugal pumps draw water and deliver it to the elevated service tank shown in Fig. 2. These pumps are driven by 25-hp. General Electric motors, and run at 1800 r.p.m., delivering 450 gal. per min. Besides these, there are 2 100-gal. per min. De Laval centrifugal pumps which supply water to the softening system, and are also driven by General Electric motors at 1800 r.p.m.

Water used for feeding the boilers is principally the condensate from the surface condensers; make up water is first treated by the Booth softening system which has a capacity of 10,000 gal. per hr. From the softener the water goes to a 4000-hp. Cochrane open heater provided with a Lea V-notch meter, located on the gallery floor in the boiler room between the 2 stacks. Exhaust steam from the various auxiliaries is used for heating the water which leaves the heater at a temperature of from 200 to 212 deg. F.

From the heaters, 2 Westinghouse, turbo-driven, 3-stage centrifugal pumps deliver the water to the economizers at a pressure of 285 lb. A double system of piping is employed for the feed water, both to and from the economizers, and the piping to the boilers is arranged on the loop plan. Besides the meter on the heater, there is a Lea V-notch meter on the discharge line from each condenser.

Steam at 210 lb. pressure and 125 deg. superheat is carried from the boilers to a 7-in. header for each battery of boilers. The plant is designed upon the unit system, 2 boilers being sufficient to carry one turbine so that from the header of each battery a pipe is run under the floor to a turbine. There is, however, a cross connection in the basement which gives flexibility to the system.

In the boiler room is also a Westinghouse air compressor which furnishes air for blowing and cleaning purposes about the plant.

The bottoms of the stacks are fitted out as rooms with entrance from the basement and are used to store oil, valves, fittings, etc.

The sump pit is also located below the boiler room; waste water collecting here is pumped to the river by a 5-hp. float controlled, vertical motor-driven centrifugal pump.

On the roof of the boiler room is located the condenser of the Holly drip system, also exhaust heads for the heater and atmospheric relief for the turbines.

Turbine Room

Here 2 turbo generators are installed and space is allowed for 2 more of the same capacity. The units, which were manufactured by the Allis-Chalmers Manufacturing Co., generate current at 2300 v., 3 phase, 60 cycles, and have a maximum current capacity of 1645 amp. per terminal. To supply field for these generators,

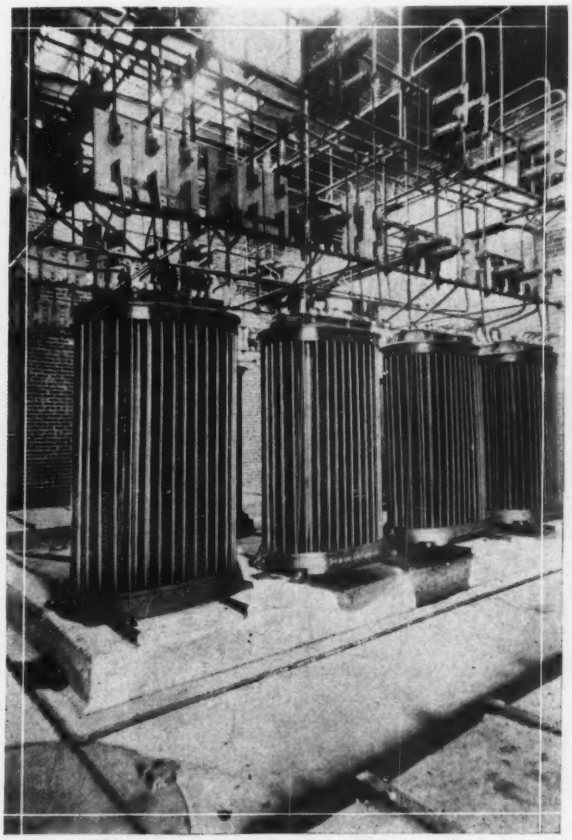


FIG. 4. SET OF TRANSFORMERS; SPARE UNIT AT LEFT

3 exciter units are provided. Two of these are Westinghouse turbine driven machines, run at 3000 r.p.m., rated at 50 kw., and develop current at 125 v. The third is a motor-driven set consisting of a 60-hp. a.c. induction motor, run on 2300 v., direct-connected to a 40-kw., 125-v., d.c. generator and runs at 1140 r.p.m.

Serving the main turbines are Westinghouse surface condensers placed in the foundation of the turbine. Each has a cooling surface of 8500 sq. ft., and the vacuum carried ranges from 29 in. during cool weather to 28.5 in. when the cooling water reaches 70 deg. F. The circulating pump is of the centrifugal type, driven by a turbine through a reducing gear, the speed of the turbine being 3000 r.p.m.; that of the pump 600. A

Le Blanc pump takes care of the air and noncondensible gases, and the same shaft has a centrifugal pump delivering the condensate to the feed water heater. The condensing apparatus for 1 turbine is shown in Fig. 3.

Control of the electrical output is from the switchboard in the turbine room. The benchboard and switchboard are on the same floor as the turbines, but the high tension switches and bus bars are in the basement.

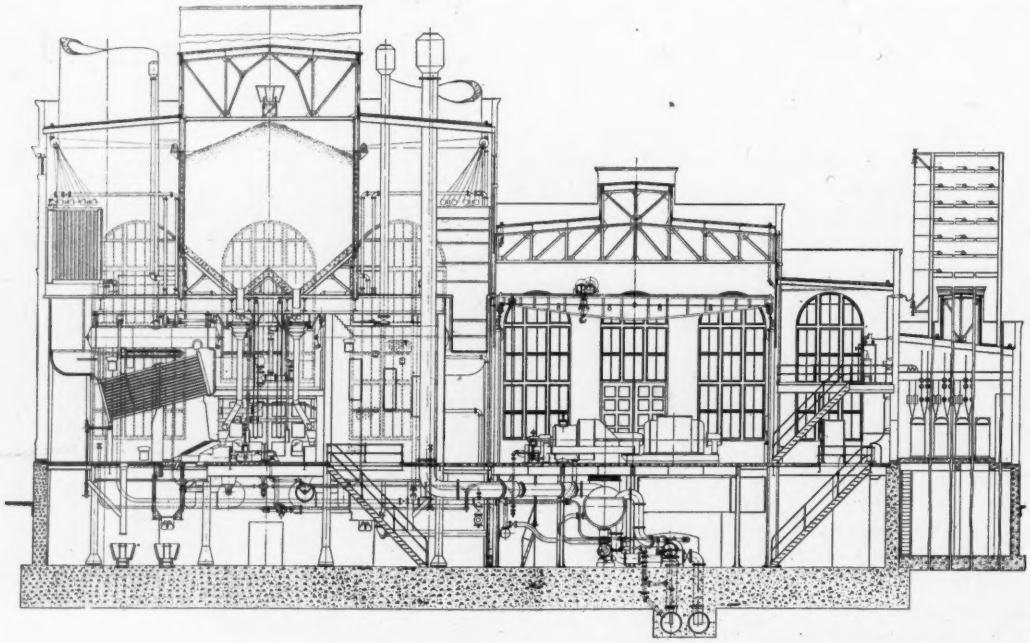


FIG. 5. CROSS SECTION OF POWER HOUSE

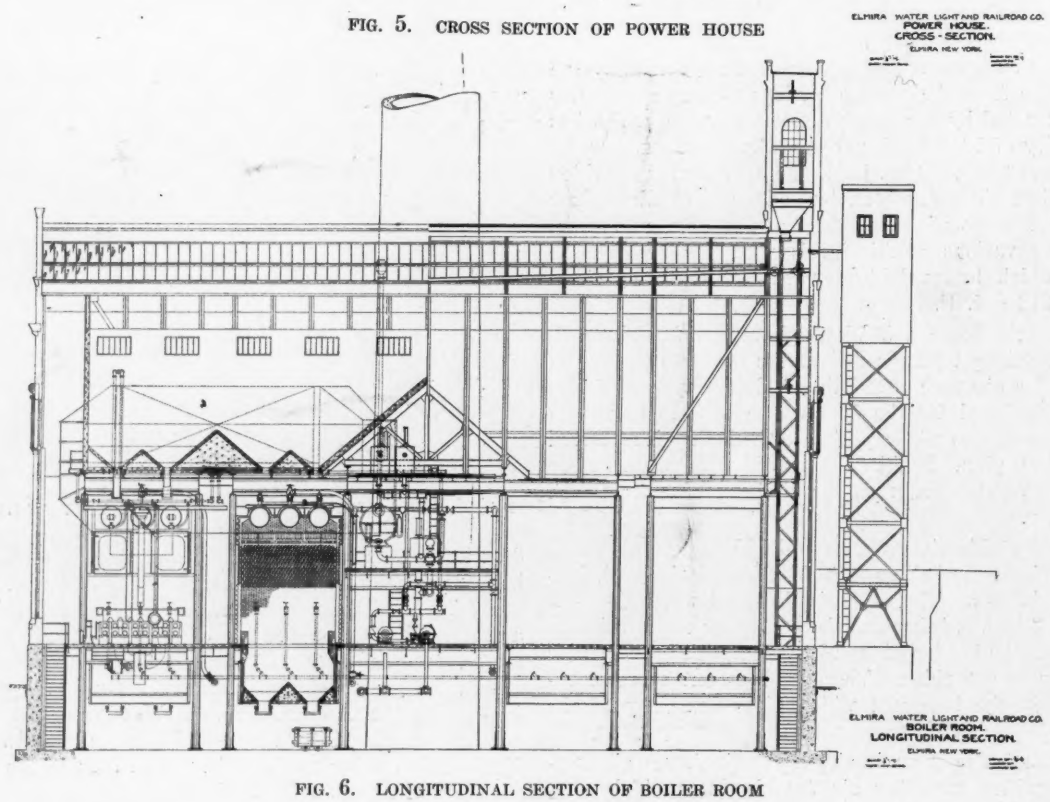


FIG. 6. LONGITUDINAL SECTION OF BOILER ROOM

Condensing water is drawn from the river through a 42-in. intake and discharged farther down stream through a pipe of the same size.

The benchboard is directly in front of the switchboard with ample space between for the operator. There are 5 panels in the benchboard, one for each generator,

and one, in the center, for the exciters. The fourth and fifth panels are, however, blank at present, but will be used for future generators. Above the bench is an open space which allows the operator to see how the turbines are operating, and above this are short panels upon which are mounted the instruments.

The switchboard consists of 21 panels, all used to control feeder lines. Low voltage only is carried to the switchboard, all high tension switches and circuit breakers being electrically operated from the board, and located in cells in basement. The voltages carried on the buses in the basement are 2300, 6600, 11,000 and 22,000, all bare copper. All switching apparatus is the product of the General Electric Co.

In a gallery above the switchboard are the electrolytic lightning arresters and the storage battery of 35 amp.-hr. capacity, used to furnish current for the remote control switches and emergency lighting of the plant.

The transformer house is next to the switching department, shown to the left in Fig. 2. There are at present 3 sets of 4 transformers arranged as shown in Fig. 4. These are all single phase transformers, 3 being connected in delta with one as a spare so wired up with the others that it may take the place of any one of them by merely operating the switches. Two sets were made by the Wagner Electric Mfg. Co., 4 of these having a capacity of 1200 kv.a. each, 60 cycles, with a voltage ratio of 2200 to 7260; the other 4 are rated at 300 kv.a., with a transformation ratio of 2400 to 22,000, all water cooled.

Another set of 4 are General Electric transformers, each with a capacity of 145 kv.a., and a voltage ratio of 2200 to 11,000 or 22,000, self-cooled.

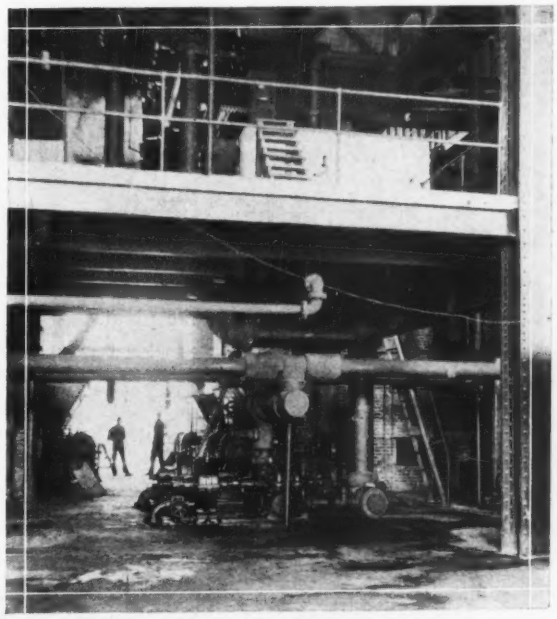


FIG. 9. BOILER ROOM, SHOWING FEED WATER HEATER, METER AND FEED PUMPS

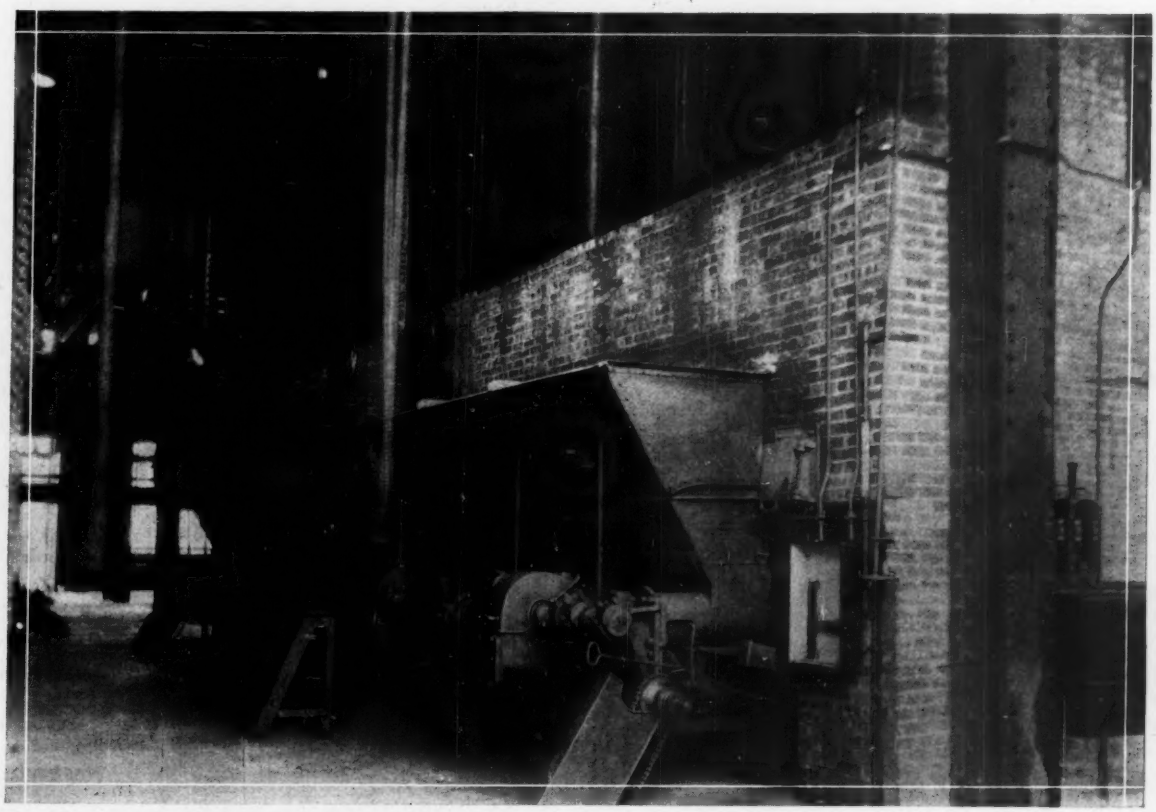


FIG. 7. VIEW OF BOILER ROOM

In the transformer house a system of industrial rails makes it comparatively easy to slide a transformer from its location onto a truck which is pushed to a crane compartment, where it may be lowered through a hole in the floor to remove the inside parts.

The high tension wires are taken directly from the transformer room to bus bars in basement, then up wall of engine room, then through wall to the distributing rack on top of transformer house, which is shown in Fig. 2.

A striking feature of this plant is the method of keeping track of the operation of the machinery. Mention has been made of the recording instruments as they are applied to the various pieces of apparatus; it is interesting, however, to see how these may be used to secure the best over all results from the plant.

Finally the wattmeters on the generators give the load at the switchboard and the chief engineer has most valuable information from which he can work up operating directions for his men to meet all conditions which are likely to occur in the plant.

The result of this system of records is a continuous test, the readings of which are obtained automatically, the charts are collected and curves plotted daily by a clerk in the engineer's office.

The design and construction of the plant is the work of J. W. Thomas of the United Gas & Electric Engineering Corporation, New York City, and its operation is in charge of A. C. Jordan, Superintendent of Generation, to whom as well as to F. H. Hill, the General Manager of this property, we are indebted for information and courtesies during the preparation of this article.

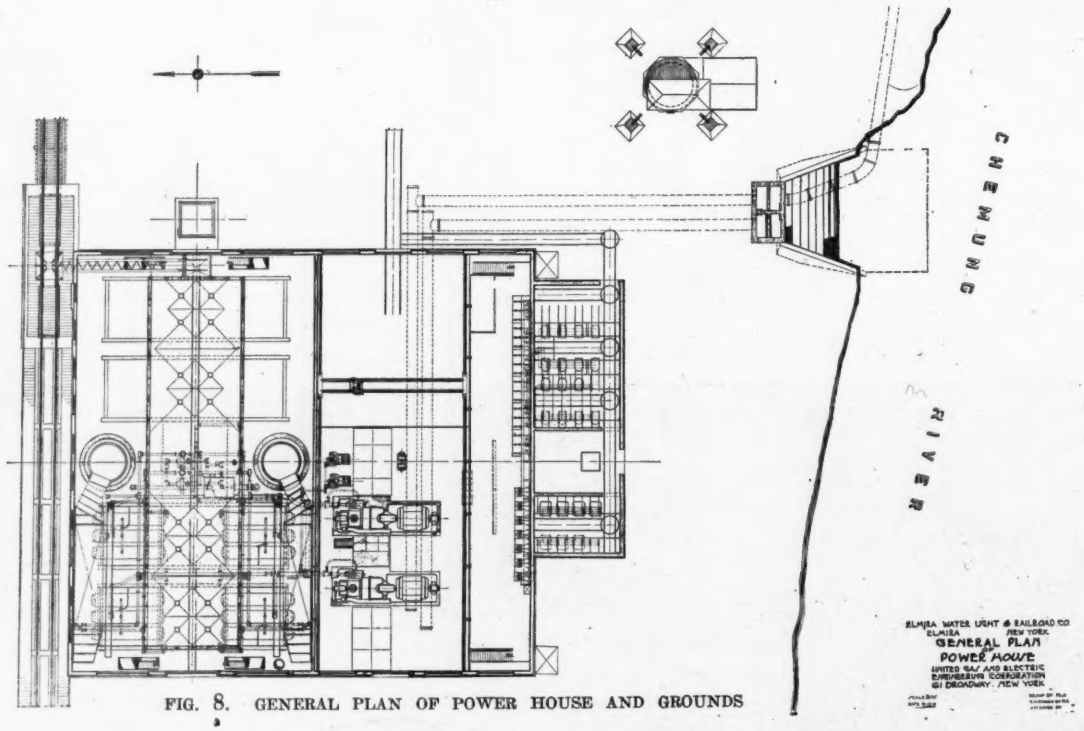


FIG. 8. GENERAL PLAN OF POWER HOUSE AND GROUNDS

Coal is weighed in cars and again just before being fired, also estimated from strokes of stoker; these weights should tally. Feed water is measured as it leaves the condensers and again as it comes from the heater.

Temperatures of the feed water in and out of the heater, and in and out of the economizer are automatically recorded, as are also the flue gas temperatures in and out of the economizer, all of which should have definite relations to each other.

The amount of steam delivered by each boiler is graphically recorded, the pressure and temperature also play an important part and an automatic record is kept of them. The percentage of CO_2 in the flue gas from each boiler is determined and recorded automatically and continuously. Then the vacuum produced by the condensers, temperature of condensing water at inlet and outlet have a bearing upon the operation and are therefore recorded in this plant.

NEAR PITKIN, Colo., the hydro-electric plant of the Brandt Mining Co., is nearing completion. The dam is 250 ft. long, a double row of piling being driven from 5 to 7 ft. into the ground, a heavy interlacing of logs piled between these rows, and the whole covered with a rock and earth fill 12 ft. high, and about the same thickness at the bottom. Spillway and sluiceway are of concrete.

From the dam, a 44-in. pipe of 2-in. staves held together by iron bands 8 in. apart, laid on a substantial foundation, and back filled, leads 6625 ft., with a fall of 120 ft. from intake to turbines. At the power house end, the pipe divides in a Y to supply 2 15¼-in. horizontal scroll case turbines which run at 900 r.p.m. under an effective head of 110 ft. and deliver 200 hp. each. Direct-connected to each wheel is a 150-kv.a. generator delivering current at 2300 v. to transformers which step up to 6600 v. for the 3-mile transmission to Camp Bird Mine where it is stepped down to 440 v.

Public Service Rates

COST OF SUPPLYING POWER FOR VARIOUS CHARACTERS OF SERVICE AND THE RETURN THEREFROM. BY HENRY D. JACKSON

FEW people realize the size of the business of a large electric supply corporation, and still fewer are aware of the enormous amount of money which must be invested in the business, or the tremendous expense in operation.

The first is the power station, sufficient in capacity to meet the maximum demand which may exist. This demand is variable, being comparatively small in the daytime during the summer, and exceptionally large in the evenings during the winter. This winter demand is the one which must be met and which requires the enormous investment in the form of apparatus in the station, in order that the power may be generated and distributed. The station must be located where coal can be secured easily and at a minimum cost, for coal is a heavy item of expense. It must be located also where the ashes can be easily disposed of, for the amount of ash from the coal is very large; and unless this ash can be easily gotten rid of, the expense of disposing of it may be quite great. Water for condensing purposes is of enormous importance, and the station must be so located that this water can be secured cool and in large quantities. The amount of water required is almost beyond belief. For instance, a station having a capacity of 50,000 kilowatts and operating to its capacity, will require each hour 5,940,000 gal. of water. These enormous figures show clearly the necessity for the plant being located at or near a large water supply.

LOCATION OF PLANT AND INVESTMENT REQUIRED

THESE conditions often require that the station be located a long distance from the center of load, which in turn implies that the power has to be carried from the station a long distance before it reaches any considerable proportion of the load. It is vitally important that sufficient land be purchased in the immediate vicinity of the power station to insure room for future growth, as well as storage capacity for coal in case of delayed deliveries. Thus the primary cost of a plant with its equipment, buildings, and land is exceedingly heavy. One large plant has expended for its steam end $5,300,103, and for its electric end $5,353,294.

Not only must the power plant be housed, but there must also be sub-stations for the necessary machinery to properly distribute this power in the different localities, transformers of various types being located in these stations where the voltage of the main transmission line is lowered to the voltage required on the distributing line. There is also required the office building or buildings for the housing of management and engineering forces. These require the purchase of real estate to the extent of $8,144,448.

Extensive transmission lines are required—first, for the transmission of power from the main station to sub-stations, and second, from there to the distributing lines and from these lines to the individual customers. The cost of such lines is exceedingly heavy, amounting to $13,874,726. Transformers are required for transforming the voltage from that of the distributing lines, to that used for the service and house lines, requiring an additional expenditure of $627,249. For the purpose of recording the amount of power delivered to the individual customers, meters must be purchased at an expense of $1,144,862. For supplying light to the various cities and towns, arc lamps are purchased to the extent of $410,259; and for other items in the way of supplies and materials, there is required a sum of $1,495,092. In order to increase the business, other properties were purchased at various times during the year, to the extent of $2,011,726, making a total expenditure of $38,564,764, and bonds are issued to the extent of $1,413,000—all of which shows the tremendous amount of capital which has to be invested in a large public service corporation to supply light and power to a large city and its surroundings.

OPERATING COST AND OUTPUT

THE operating costs of such a plant are large. The expense at the station for the generation of power and keeping the plant in operating condition were $1,158,555, of which the coal cost was $634,868, thus showing the enormous extent to which the cost of coal affects the operating cost of the plant, and showing the necessity for the coal arriving at the lowest possible cost. The expense of distributing the power and taking care of the transmission lines was $718,314. Management expense was $735,627. Unquestionably a considerable portion of this management expense is the engineering staff required for the obtaining and maintaining of the business of the large consumers of electricity in the form of both power and light. Taxes on the plant and investment represent $797,617, and incidentals $171,679, making a total of approximately $3,581,792.

The total output of the station at the switchboard was 171,783,312 kw.-hr. A large proportion of this power is either lost in transmission or utilized throughout the plant for advertising and other purposes, so that but 122,830,814 kw.-hr. were actually sold and returned an income to the company, thus showing that but 71.5 per cent of the station output was actually delivered to paying customers. Therefore, the cost of power to the company so far as power sold is concerned, is not represented by the cost per kilowatt-hour generated, but is represented by the cost per kilowatt-hour sold, so that the cost of power at the station is 0.944 cents, which is much higher than is usually considered as the power cost at the switchboard of a large generating station.

This, however, represents a small proportion of the total power cost. This power being generated, it must be distributed, and the distributing costs are heavy. The management details must be paid for, interest on the bonds and investment have to be covered, as well as taxes and incidentals before the total costs are completed. The total operating costs per kilowatt-hour sold are 2.919 cents. To this must be added the interest on the bonds and dividends, or 1.915 cents, making the total cost of

the power which must be covered in order to show the interest paid, of 4.834 cents as an average, thus showing that the station costs are but about 1/5 of the total cost of power to the plant.

Depreciation

In all financial transactions where machinery and plant are required, it is usual to consider depreciation charges very carefully, for it is well known that machinery and buildings and transmission lines, or in fact all material things, depreciate with more or less rapidity. The more rapidly they depreciate, the greater the necessity for setting a sum aside for covering this depreciation, in order that the plant may not become obsolete and no money at hand to replace it. The central stations, when figuring on installing power in an isolated plant, assume depreciation at rates varying from 5 to 15 per cent. It is well known that machinery in most isolated plants continues in operation from 20 to 30 yr. if well taken care of, and, therefore, a depreciation of 3 to 5 per cent is, or should be, sufficient to cover these cases.

Let us examine into the central station depreciation account. The land on which the plant is built may not depreciate, depending upon its location. The buildings depreciate slightly, as do some parts of the transmission lines and other items of the investment; but the steam and electric plant depreciates or goes back very rapidly, not perhaps because these devices are worn out, but because better types are constantly being made of both characters. No large public service corporation or any other, can afford to keep machinery in service when new types are built which will save in their operation enough to scrap the old and install the new, and this is the cause of the rapid depreciation in such machinery. In some cases a depreciation, or, as it is frequently termed, "amortization" charge of 10 per cent is none too much to cover such items. Under the conditions then, it is fair to assume that the depreciation or amortization rate on the steam and electric plant will be approximately 7 per cent. This means $647,737; assuming that ¼ of the real estate is represented by buildings and that these depreciate at the rate of 2 per cent would require $40,722. The lines depreciating at the rate of 4 per cent would require $554,989; meters at 2 per cent $22,897; arc lamps at the rate of 2 per cent would be $41,825, making a total depreciation fund at these low rates of $1,307,372, or making the total depreciation charge at the rate of 1.063 cents per kilowatt-hour. This added to the cost of power would make the total cost 5.897 cents. The total receipts were 5.2 cents, which would indicate that these charges, small as they are, have not been taken into account. As a matter of fact, after all dividends, interest and other charges have been paid, the total amount left for depreciation and placed in the fund for reserve, amounted to $558,587, or but 43 per cent of that required for a low allowance for depreciation, thus showing conclusively that the central stations, at least in this regard, work on a totally different principle when applying figures to their own plants from that when figuring on somebody's else plant.

Service Requirements

Service rendered by the central station is tremendously varied. Power is delivered to a large variety of customers represented by offices, private houses, stores, factories, advertising signs, and street lights, as well as numerous services difficult to characterize. Practically every customer is different, and power may be required at any time during the day or night, thus requiring that the station be in operation at all times and prepared to deliver power to each and every customer when that customer may desire it.

The majority of the customers are those requiring power for light, and using power mainly during the dark hours of the 24. There are, however, numerous of these customers who require light during the day-time in locations where other light is not obtainable; also many of these have use for small pieces of apparatus, too small to be classed as power, which are in use at all times of the day and night, such as small fans, motors, etc. The large lighting customers, such as the large stores and many of the factories, require light during a large portion of the day in many places, but their peak load comes during the dark hours of the day and exists only during the day. These stores and factories require this power during but 6 days of the week and only during working hours. The factories require power during the day-time from 7 to 8 o'clock in the morning to 5 or 6 o'clock in the evening. The advertising signs come on at dusk and run varying hours, depending on the character of the advertising. The street lights come on at dusk and continue until dawn. Thus it will be seen that the loads exist at various times during the day, but that practically all of them exist during the hours from 4 to 7 in the winter.

The number of customers of all characters was 52,447; those of light alone were 43,472, showing to what a tremendous extent the lighting load preponderates, and showing further that the lighting load is the load which is by far the most important to the central station. The total customers using power alone were 1392; those using light and power 7073; the balance were those using apparatus not enumerated. It is to be noted, therefore, that power for light represents by far the greatest number of customers to the plant. It is, therefore, important to note the relative connected loads of the 2 most important characters of current; that is, for light and for motive power. The total connected load for light was 105,256 kilowatts; the total connected load for power was 69,881 kilowatts; or the power load is approximately 66 per cent of the lighting load. The total amount of electricity sold for power is but 38 per cent of that sold for commercial lighting. The income from that sold for power is but 29.7 per cent of the income for commercial lighting, yet the peak loads of the 2 types show that the power peak is 82 per cent of that required for the commercial lighting, which would indicate that the relative investment as regards equipment for power would be closely approximating that required for light, and that as the load for the lighting was vastly greater than that for power, the cost per kilowatt-hour for the power for motors would be greater than the cost per kilowatt-hour for light, under which conditions one would suppose that electricity would be sold at a higher price for power than for light.

Peak Capacity

We are frequently told that the central stations can afford to sell electricity for power at a low price as compared to that for light, because no additional ma-

chinery is required for power over that which would be required for the peak of the lighting load. Therefore, the costs of this machinery and the distributing apparatus do not need to be charged against power customers, the sole cost to the company for them being the operating costs at the station and the distributing and management costs of handling the power. It is, therefore, worth while to examine somewhat into the necessary equipment to see whether the above claim is justified, before we look into the actual return from the power customers.

The peak load of the lighting customers occurs at various hours during the year, being late in June and early in December, varying from 7 or 8 o'clock in June to 4 or 6 o'clock in December. The peak load of power may occur during the hours of from 4 to 6 all the year around. Therefore, in December the peak of both power and light occur together under which conditions there will be required in the station and in the streets, apparatus equal to the combined peaks. It matters not that this condition of affairs lasts but 2 or 3 months and but for a few hours each day. The fact that these 2 peaks occur at the same time during any portion of the time, necessitates apparatus equal to the combined load. This, therefore, entirely upsets the central station idea that electricity for power can be delivered from the apparatus utilized to cover the peak load of the lighting. Therefore, the fixed charges on the apparatus required for delivering the power should be charged against those making it necessary, otherwise, they are not paying their proportion of the costs; and as these costs must be paid, they must be charged up against the customers who are not responsible for it—in other words, the lighting customers. This, however, must not be taken in its broad sense. It does not apply to all of the lighting customers. It applies only to those who are not in a position to produce their power for themselves. In other words, the large lighting customers who can produce their light at a low price are charged a low price exactly the same as those who use large amounts of electricity for power and the fixed charges on their apparatus is also charged up against the small user.

Some Power Transmission Economics

Comparison of Relative Costs of Rubber Belt, Stitched Canvas Belt and Manila Rope Drives. By Reginald Trautschold

UNIVERSAL as is the transmission of power by endless belts, it is not the oldest system of distributing power. Ropes were used in power operations centuries before the modern belt was evolved and today there is a strong tendency to revive this early method.

Disregarding precedence and general practice, the main requisite of a flexible band for transmitting power, provided sufficient area of contact can be secured on the driving and driven wheels to obviate slippage, would be maximum strength with minimum weight. Of the common materials, a steel bar offers about the greatest strength for its weight but is entirely too rigid for power transmission purposes unless made in thin belts necessitating great width for the requisite strength. Ropes constructed of steel or iron wires are more adaptable; but they are not flexible enough for general use, requiring large sheaves on account of their comparative rigidity. Manila rope, as is not generally recognized, is practically as strong—weight for weight—as a steel bar and is quite flexible enough for general power transmission purposes. Its tensile strength is about 2½ times as great as that of leather belting and considerably greater than that of the stronger rubber and stitched canvas belts. It then offers advantages for power transmission purposes which are rapidly becoming recognized. Without going into an exhaustive discussion of manila rope power transmission or a detailed explanation of equipment requirements, etc., the economic advantages of this transmission system will be briefly touched upon.

Two general systems of manila rope transmission are in vogue; the American, or continuous, system, consisting of one long endless rope wrapped about suitable sheaves as often as is required for transmitting the required power, one wrap being able to transmit but a comparatively limited amount of power; and the English, or multiple, system, consisting of a number of endless ropes running in adjacent grooves on the sheaves. Both systems have advantages and disadvantages. The American system, the more complicated, is the more adaptable, readily accommodating itself to quarter-turn drives and to installations where the driving and driven sheaves lie in planes oblique to one another. With suitable tension carriages, a uniform and constant tension is maintained throughout the system; but, on the other hand, should the rope break at any point the whole system is thrown out of operation. The system is also somewhat more expensive to install than the simpler English system. The English system is particularly adapted to installations where power has to be delivered from the main driving sheave to several floors or to several independent sheaves and as each rope is an independent drive in itself, the breaking of a rope does not necessarily cripple the entire system, for the broken rope may be replaced at some convenient opportunity, the plant in the meantime operating on the remaining ropes. There is difficulty in keeping the same tension in all of the ropes, however, but this drawback is not as serious as might be supposed. Quite apparent difference in the slack of the various ropes may exist without seriously affecting the amount of power that each rope transmits for all ropes travel at the same speed, unless excessive slippage occurs where the tension is the lightest, and the slacker ropes have slightly greater arcs of contact on the sheaves, tending to augment their power transmitting capacity, thus compensating for the decreased tension.

Efficiency in rope transmission requires high rope speeds. Theoretically, the most advantageous speed for a rope drive would be about a mile a minute, at which speed the loss due to centrifugal force exceeds the gain in power due to increased speed. In addition to the

loss due to the centrifugal force acting on the rope, however, is the air resistance to the passage of the rope, negligible at low speeds but marked at high speeds. These detracting agencies somewhat lessen the speed at which the greatest power can be secured, so that the most efficient speed for practical purposes is about 4500 ft. per min. Chart X graphically depicts the power that can be developed with various standard sizes of Manila

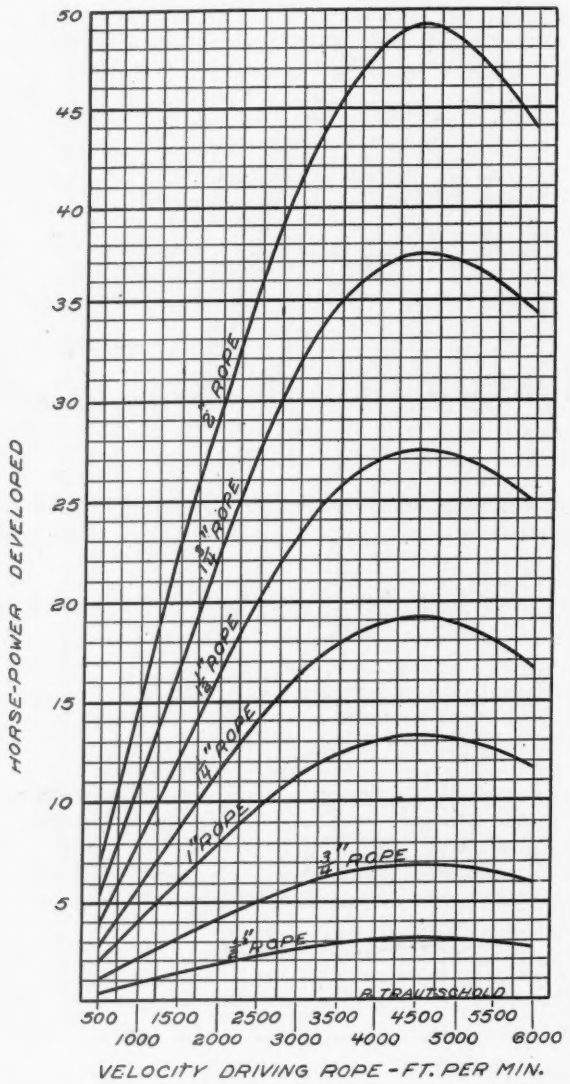


FIG. 1. (CHART X) SHOWING RELATION BETWEEN HORSEPOWER AND VELOCITY OF MANILA ROPES

transmission ropes in an efficient installation, traveling at speeds of from 500 to 6000 ft. per min.—180 deg. arc of contact between rope and sheave. The high advisable rope speed and the necessity of minimizing the number of bends that the rope is called upon to make, in order to prolong its life, necessitate sheaves of considerable diameter—the minimum advisable diameter of sheave being about 40 times that of the rope employed.

Charts XI and XII of Practical Reference Tables show the comparative cost of high-grade manila rope and of sheaves of such ropes respectively, by the use of which the economic value of a manila rope drive compared to a belt drive can be readily and conveniently ascertained, the cost of shafting, bearings, etc., required in any case not seriously affecting the comparison, as they cost about the same for either type of drive. As a simple drive will well serve as a basis of comparison of the relative economy of a manila rope and of a belt drive, it will be assumed that 250 hp. is to be transmitted from a generating unit operated at 180 r.p.m. to a main distributing shaft situated 50 ft. distant and which it is desired to drive at 270 r.p.m. In the case of a belt drive—efficient transmission of power being possible at a belt speed of 3000 ft. per minute—the main driving pulley may be taken as 64 in. in diameter, necessitating a 40-in. pulley for the distributing shaft. In the case of manila rope transmission system, the advisable diameter of sheaves would be 96 in. and 60 in. respectively.

A leather belt capable of transmitting 250 hp. at 3000 ft. per min. would necessarily have to be so wide as to be very costly, so that the economic practice would be to use a heavy built-up belt. A 10-ply rubber or a 10-ply stitched canvas belt would be about as heavy a standard belt as would be obtainable and a 21-in. rubber or a 30-in. stitched canvas belt—see Chart VIII of the Data Sheets, Oct. 15, 1914, issue—would have to be installed. Nine 1½-in. manila ropes traveling at 4500 ft. per min. would transmit the same power (see Chart X) and a sheave for 9 1½-in. ropes is only about 16 in. in width. This saving in width is simply emphasized, as it may be a vital question in an installation where available space is at a premium.

With the foregoing conditions fixed, it is a simple matter to arrive at an accurate estimate of the comparative cost of any of the 3 power transmission systems (see example given). Should the American system of rope transmission be installed, the cost of the rope installation would be increased only by that required for a suitable tension carriage and weights, in the particular case under consideration costing about $60, savings that would make it advisable to scrap the main driving pulley, should that have been furnished with the power unit, maintenance charges, etc., of a manila rope system being less than that of a belt drive.

Under the conditions considered, there was no need to correct for arc of rope contact, for with sheaves 50 ft. apart, the sag in the upper rope runs—the driving side of a rope drive being nearly invariably the under side—would be sufficient to give at least a 180-deg. wrap on the smaller sheave. Instances do arise, however, where it is impossible to secure an arc of contact of 180 deg. and correction of power as obtained from Chart X must be made accordingly. The necessary allowance to make is graphically depicted on Chart XIII.

EXAMPLE

LET IT be required to find the relative cost of rubber belt, stitched canvas belt and manila rope drives. Two-hundred-fifty horsepower is to be transmitted 50 ft. and the speed of the driving shaft is 180 ft. per min., while that of the driven shaft is 270 ft. per min. Belt speed is to be 3000 ft. per min., and rope speed, 4500 ft. per min.

The equipment required will be as follows:
(Rubber belt drive.)
115 ft. of 21-in., 10-ply rubber belting;
One 64 by 21-in. split C. I. pulley;
One 40 by 21-in. split C. I. pulley.
(Stitched canvas belt drive.)
115 ft. of 30-in., 10-ply single canvas belt;
One 64 by 30-in. split C. I. pulley;
One 40 by 30-in. split C. I. pulley.
(Manila rope drive.)
1150 ft. of 1½ manila transmission rope;
One 96-in., 9-groove sheave for 1½-in. rope.
One 60-in., 9-groove sheave for 1½-in. rope.

Comparative costs

Considering first the rubber belt drive, we find from Chart IX, in the Oct. 15 issue, that the comparative cost of a 115-ft. length of a 21-in., 10-ply rubber belt would be equal to $115 \times 15.75 \times 2.05$, or 3713. In a like manner, by reviewing Charts VI and VII in the Sept. 15 issue, we find the comparative costs of 64 by 21-in. and 40 by 21-in. split C. I. pulleys to be $23 \times 7.2 \times 10 = 1656$, and $10 \times 7.2 \times 10 = 720$ respectively, making a total of $3713 + 1656 + 720$, or 6089.

In a similar manner, we see that for a stitched canvas belt, the comparative cost is $115 \times 18.75 \times 2.05$, or 4420, and for a 64 by 30-in. and a 40 by 30-in. split C. I. pulley, the comparative costs are 2668 and 1160 respectively. This makes a total of 8248.

Now considering the manila rope drive, we see by consulting Chart XI, that the comparative cost of the 1150-ft. length of rope will be $11.5 \times 7.8 \times 16.25$, or 1458. From Chart XII, we find for a 9-groove, 96-in. sheave, a comparative cost of $32.4 \times 1.375 \times 1.1 \times 56$, or 2744. For a 60-in., 9-groove sheave, this cost will be $13.5 \times 1.375 \times 1.1 \times 56$, or 1144, making for the rope drive equipment a total of 5346.

We now find the relative economy to be as follows (rubber belt drive vs. manila rope drive):

Rubber belt drive	6089
Manila rope drive	5346
Relative economy	743

(Stitched canvas belt drive vs. manila rope drive.)

Stitched canvas belt drive	8248
Manila rope drive	5346
Relative economy	2902

Rope drives, though often resulting in and frequently promising decided economy, cannot entirely supplant belts for the transmission of power. They are particularly adapted to handle comparatively large quantities of power, as much as 5000 hp. being handled over one drive; but when it comes to furnishing an individual machine with power, the size of the necessary sheaves frequently makes a rope installation out of the question. The economically equipped plant is the one where ropes are employed whenever practical and their limitations realized, employing belts where such are more adapted.

Capacity and Power of Pumps

Method of Determining Capacity of Pumps; Power Required for Pumping Water Under Various Conditions. By Charles L. Hubbard

Capacity of a piston or plunger pump is given by the formula, $G = D \times L \times N \times S \times C$, in which

G = gallons discharged per minute,
D = piston displacement per inch of stroke, from Table 1, Reference Tables.
L = length of stroke, in inches.
N = number of strokes per minute,
S = factor for "slippage" from Table 2,
C = number of cylinders.

Table 1, of Practical Reference Tables, has been computed for use with the above formula and gives the displacement in gallons per inch of stroke for pistons or plungers of different diameters. Table 2 gives "slippage factors" for different types of pumps. These are equal to 1 minus the per cent of slippage, as previously given.

Example: What will be the capacity of a duplex piston pump, having 12-in. cylinders and a 20-in. stroke, while running at a speed of 50 strokes per minute?

$0.49 \times 20 \times 50 \times 0.85 \times 2 = 833$ gal. per min.

In practice, it is usually best to obtain tables of pump ratings from the manufacturers, together with guaranteed "slippage factors" for average conditions. This simplifies the process of computation, as it may be made to cover all types and sizes of pumps and also places the responsibility of the result upon the makers.

Power Required for Pumping Water

Theoretical horsepower required for elevating water is given by the formula,

HP. = $(W \times H) \div 33{,}000$, in which
HP. = the "water horsepower,"
W = pounds of water raised per minute,
H = height of lift, in feet.

In practical work, the quantity of water handled is usually expressed in gallons. Furthermore, the frictional resistance of the supply and discharge pipes must be considered and also the mechanical efficiency of the pump. Taking these into account, we have for a working formula

D.HP. = $(G \times H) \div (4000 \times \text{Eff.})$, in which
D.HP. = delivered horsepower required to operate the pump,
G = gallons discharged per minute,
H = total head = friction head in pipe line plus the lift, both taken in feet.

Example: What D.HP. will be required by a pump having an efficiency of 60 per cent, to raise 160 gal. of water per minute a height of 50 ft. through a 4-in. pipe 1500 ft. in length?

The friction head for a 4-in. pipe 1000 ft. long is 29.1 (at the velocity required for the given quantity of water); making the total head pumped against $(29.1 \times$

1.5) + 50 = 94 ft. Substituting in the formula, we have
D.HP. = (160 × 94) ÷ (4000 × 0.6) = 6.2.

Pump Efficiency

Mechanical efficiency of a direct-acting steam pump is taken as the ratio of the water horsepower to the indicated horsepower of the steam cylinder.

In the case of power pumps of different kinds, driven by separate engines or motors, the mechanical efficiency is the ratio of the water horsepower to the input or delivered horsepower.

In the air lift, the ratio of the water horsepower to that required by the air compressor is taken. Table 3 gives in tabulated form the average efficiency for different types of pumps in common use.

The steam consumption of a direct-acting pump of the type commonly used for boiler feeding and elevator service will vary somewhat according to size, but may be taken approximately as in Table 4.

Power for Air Lifts

Air pressure required for raising water with an air lift may be found with sufficient accuracy by dividing the actual submergence, in feet, by 2.

The volume of air required, at the given pressure, will be the same as the volume of water which it displaces, or in other words, each cubic foot of air delivered at the bottom of the well will raise 7.2 gal. of water.

From the above we have the following relations:

P = B ÷ 2; C = G ÷ 7.2; W.HP. = F × C, in which
P = required air pressure, in pounds per square inch,
B = actual submergence, in feet,
C = cubic feet of air required at pressure P,
G = gallons of water discharged per minute,
W.HP. = water horsepower,
F = horsepower factor for pressure P, from Table 5.

$$\text{D.HP.} = \begin{cases} \text{W.HP.} \times 1.66, \text{ for single-stage compressor.} \\ \text{W.HP.} \times 1.33, \text{ for 2-stage compressor.} \end{cases}$$

As compressors are usually rated according to the cubic feet of free air which they will compress per minute to a given higher or terminal pressure, it is necessary in computations of this kind to reduce the volume of air required at pressure P to its equivalent volume at atmospheric pressure (free air), which may be done by the use of Table 6.

Example: An air-lift has a submergence of 100 ft. and it is desired to secure a flow of 200 gal. per min. What should be the rated capacity of the compressor and will be the delivered horsepower for operating it?

$$P = \frac{100}{2} = 50 \text{ lb. per sq. in.}$$

$$C = \frac{200}{7.2} = 28 \text{ cu. ft. per min.}$$

F = 0.12 from Table 5.

Volume of free air corresponding to 1 cu. ft. at 50 lb. pressure = 4.4 from Table 6.

Capacity of compressor, 28 × 4.4 = 123 cu. ft. of free air per minute compressed to 50 lb. gage pressure.

W.HP. = 0.12 × 28 = 3.36.

As the pressure is less than 60 lb., a single-stage compressor may be used, calling for 3.36 × 1.66 = 5.6 D.HP.

The Contrast

By R. T. Strohm

THE boss came in an hour late,
As grouchy as could be—
His new Pierce-Arrow "48"
Had tried to climb a tree;
And as, to fix the smashed machine,
Would cost him rather dear,
He vented all his childish spleen
Upon the engineer.

The engineer was not to blame,
As very well he knew,
And in his breast a scorching flame
Of anger raged and grew.
So, when he found the stoker gone
To get a breath of air,
He saw his chance to pass it on,
And called him down for fair.

The stoker was embittered by
This undeserved abuse,
But had no other person nigh
On whom he might cut loose;
And so he gave his wrath release
And spent his fuming rage
By misadjusting every piece
From feed pump up to gage.

* * * * *

The boss came in with smiling face
And genial "hello"—
He'd beat his neighbor in a race
By half a mile or so.
And while he wrestled with his work,
His spirit of good cheer
Touched everyone, from office clerk
Down to the engineer.

The engineer was tickled by
The notice of the boss,
And thereupon felt urged to try
To cut the power loss.
To win in such a task as that,
He needed help, he knew;
So, in a plain and friendly chat,
He asked the stoker, too.

The stoker, pleased by this request,
Forgot each petty wrong,
And tried to do his level best
To help the work along.
And so that power plant was run
Upon an honest plan,
Since each believed the other one
Was acting like a man.

Practical Electrical Engineering

Indicating Instruments

INDICATING instruments for alternating-current circuits are based upon principles somewhat different from direct-current instruments; the details of the mechanism of a voltmeter and an ammeter in common use are shown in Fig. 4. These instruments consist essentially of a circular coil C, with its center point at D. A

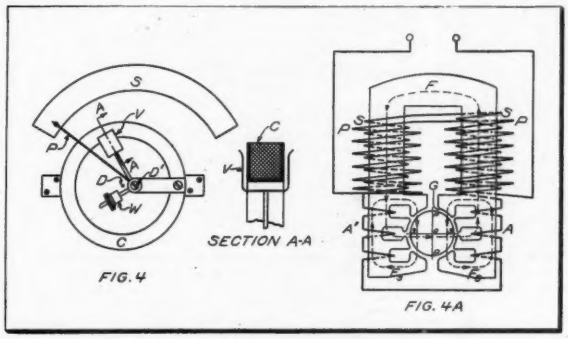


FIG. 4. DETAILS OF VOLT OR AMMETER MECHANISM
FIG. 4A. LAMINATED-IRON MAGNETIC CIRCUIT OF AN AMMETER

shaft is pivoted with its center at D^1 to the right of D and carries at the end of an arm a U-shaped piece of iron, V, which embraces the coil as shown in the lower right-hand corner. The movement of the needle is controlled by a small weight, W, which takes the place of springs. When a current flows through the coil, a magnetic field is set up, which is stronger near the coil than at its axis. The piece of iron, V, is drawn nearer the inside of the coil and swings around its center, D^1, which allows the iron to approach the coil on account of D^1 being eccentric and a deflection is thus obtained.

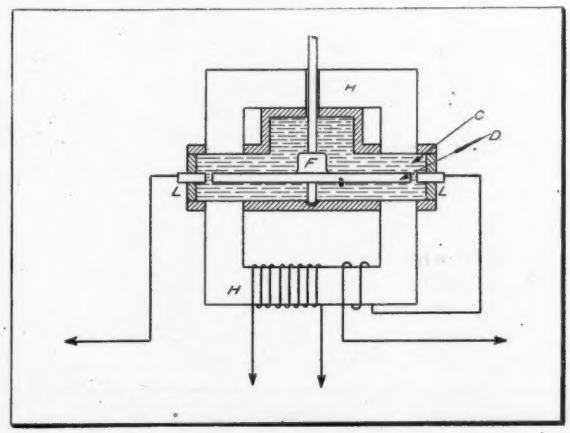


FIG. 6. DETAILS OF A SINGLE-PHASE INTEGRATING WATTMETER

Another type of indicating instrument, known as an induction instrument is largely in use at the present time. The ammeters, voltmeters, and wattmeters consist of a movement comprising a rotating aluminum drum in the air-gap of an electromagnet through the coils of which pass the currents to be measured. Such instruments may be said to differ from the moving coil electromagnet instruments in that the currents in the movable element which react upon the field of the stationary element, thus producing torque, are induced in the moving element by the transformer action of the primary coil and core, instead of being conducted into it by means of flexible spring conductors.

To understand the mechanism more fully, it will be clearer to consider it as an ordinary coil electro-magnet instrument than as an induction motor, although it is in reality a special form of induction motor. The laminated iron circuit of an ammeter is shown in Fig. 4A, with its annular air gap in which the aluminum drum is free to rotate. P represents a primary winding through which passes the current to be measured, S-S is

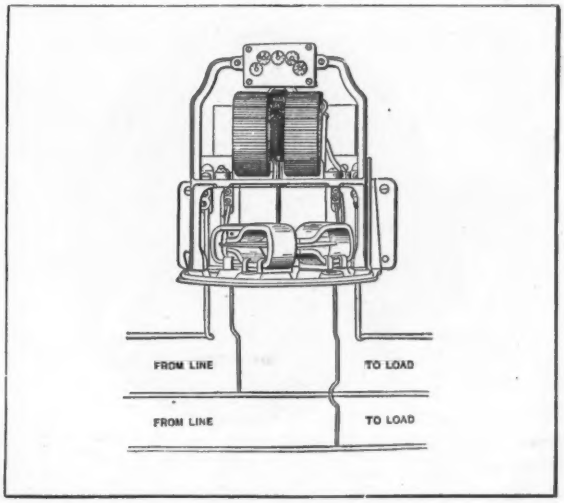


FIG. 5. CONNECTIONS OF A BALANCED 3-WIRE INTEGRATING WATTMETER

the secondary winding short-circuited on itself, and the dotted lines marked F represent the various magnetic fluxes produced by the currents in the coils.

The windings P and S are the same in relation to each other as the primary and the secondary windings of a current transformer, and their currents are similarly related. The functions of this type of induction meter can be said to resemble a combination of the actions in a current transformer and an induction motor.

Integrating Wattmeters

Some types of integrating wattmeters for alternating-current circuits are similar in principle to direct-current instruments; the connections of a balanced 3-wire integrating wattmeter are shown in Fig. 5. The construction and design of the meter are essentially the same as those of a direct-current wattmeter described in a previous article.

Figure 6 shows the details of a single-phase integrating wattmeter that differs materially in principle and construction. In the figure D is a solid copper disk, F a float supporting the shaft, H is a laminated iron core and C is a chamber filled with mercury. In the core, H, the flux which is produced cuts the disk at 2 points diametrically opposite. This induces currents in the disk which react on the core flux and rotation of the disk is the result. The flux in the core is produced by the secondary current of a series transformer and is proportioned to the load current.

Frequency Meters

This type of instrument indicates the frequency of a circuit in cycles per second. It consists of 2 induction voltmeter elements, as shown in Fig. 6A, acting on a disk which constitutes the moving element. The former tend to move the disk and the pointer shaft in opposite directions. One of the voltmeter magnets is connected in series with a resistance, and the other is connected in series with a reactance, so that any change in the frequency tends to change the relative strength of the 2 magnets and cause rotation.

FIG. 6A. INTERIOR OF A FREQUENCY METER

The disk is so shaped that as it moves, the amount of its metal under the stronger magnet becomes less than that under the weaker magnet, so that with every rotation variation between the 2 magnet strengths there is a point where the torques produced by the 2 magnets balance and the pointer comes to rest. No control spring is used with this movement, as all forces controlling the action are electro-magnetic.

Power Factor Meters

Power factor meters, the diagram of connections of which are shown in Fig. 7, are designed to indicate directly and accurately the power factor of alternating-current circuits. They perform automatically an operation that otherwise requires the simultaneous reading of 3 or more separate meters and the computation of the power factor from their indications. The meters indicate upon a graduated scale the power factor of a circuit to which they are connected.

These instruments operate upon the rotating field principle, the field being produced by the current of the metered circuit in angularly placed coils. Under the influence of the field is provided a movable iron vane or armature, magnetized by a coil whose current is in phase with the voltage of one phase of the circuit. As the iron vane is attracted or repelled by the rotating field of the current coils, it will take up a position where the zero of the rotating field occurs at the same instant as the zero of its own field. Thus its position will always indicate the phase angle between the voltage and current of the circuit. The pointer attached to the armature therefore indicates this angle and by marking on the scale the cosine of the angle the power factor is read directly.

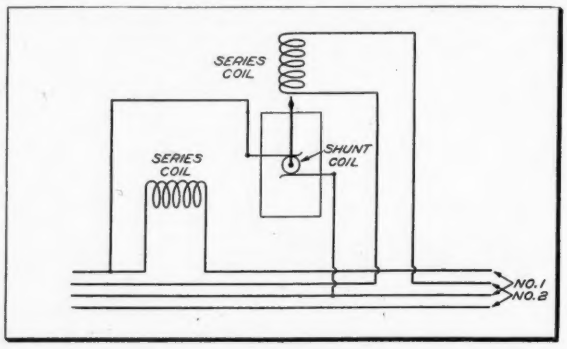


FIG. 7. DIAGRAM OF CONNECTIONS OF POWER-FACTOR METER

In the 3-phase meter, the rotating field is produced by 3 coils spaced 120 deg. apart and connected in the 3 phases of the circuit; in the 2-phase meter, by 2 current coils spaced 90 deg.; in the single-phase meter, the relative position of voltage and current coils is reversed and the rotating field is produced by means of a split-phase winding. No connection to the moving element is necessary.

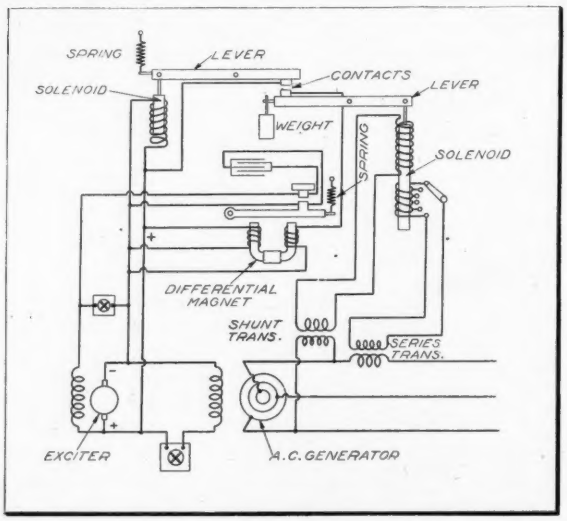


FIG. 8. DIAGRAM OF CONNECTIONS OF A TIRRILL VOLTAGE REGULATOR

Voltage Regulation

With alternating-current installations, the rheostats are similar in construction to those used for direct-current plants, but the manner of using them is somewhat different. There are 2 or more rheostats as ordi-

narily used. One rheostat varies the voltage of the exciter and the others are connected in the field circuits of the alternators as will be shown in the connection diagrams which follow. Automatic voltage regulation is used to a considerable extent, of which the Tirrill regulator is probably most extensively used. Figure 8 shows the connection diagram of this type of instrument as used with a 3-phase alternator. The solenoid shown

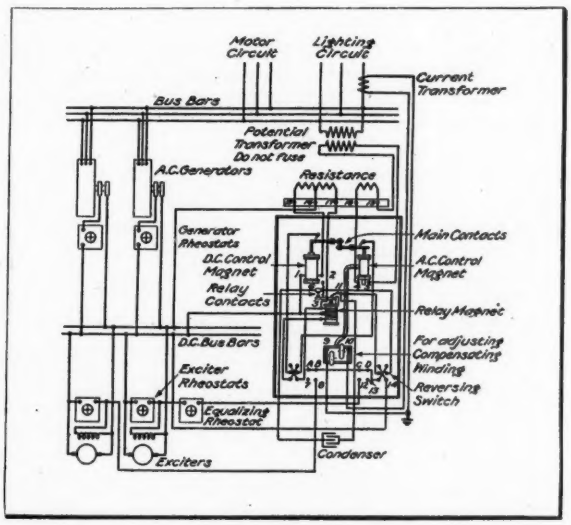


FIG. 8A. TIRRILL REGULATOR USED ON 2 EXCITERS

at the right-hand side of the diagram is connected through the shunt transformer across the circuit to be regulated; the core of the solenoid is attached by a flexible connection to a lever immediately above it, on the opposite end of which is a contact and a balancing weight.

A second solenoid is shown in the upper left-hand corner of the diagram and is connected flexibly to a lever on which is a contact that engages with that on the

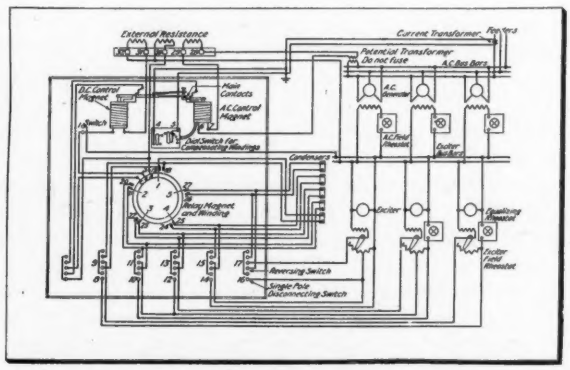


FIG. 8B. TIRRILL REGULATOR USED ON 3 EXCITERS

right-hand lever. Through the engagement of the contacts one of the 2 circuits of the differential magnet is completed, which allows the exciter field rheostat to be short-circuited by the lower set of contacts. A condenser is connected across the contacts to prevent arcing when the circuit is broken at the contact points, the condenser receiving the full voltage at the contacts at the time of break which charges it. When the contacts again engage the condenser is discharged.

Levers of the 2 solenoids, one connected across the circuit to be regulated and the other across the exciter terminals form a floating contact when the circuit voltage is low and is broken when the voltage tends to rise. By this arrangement the exciter voltage may be varied from about 70 volts to its maximum voltage.

Overcompounding is accomplished by connecting the series transformer secondary winding to the lower turns on the right-hand solenoid so as to oppose the action of the shunt coil. As the load comes on, the voltage must be increased to give sufficient pull on the core to operate the floating contact. Fig. 8A is a connection diagram of a Tirrill regulator for 2 exciters, and Fig. 8B for 3 exciters.

Potential regulators are frequently used in the feeder circuits. These were described in the transformer section.

Prevention of Sparking in the Single-Phase Series Motor

RESISTANCE LEADS AND THEIR DISADVANTAGES; BALANCED CHOKE COILS, PRINCIPLE AND APPLICATION

IT does not as yet seem possible to produce a single-phase series motor which will operate satisfactorily without some form of special device for preventing excessive short-circuit currents. The simplest device for this purpose is the insertion of a moderate amount of resistance in each commutator lead or perhaps the use of some special inductive device, the simplest of which is the balanced choke-coil arrangement.

Coils B C D E F, Fig. 1, represent the sections of an armature winding and R R R R represent resistances inserted in the commutator leads. Here is shown the

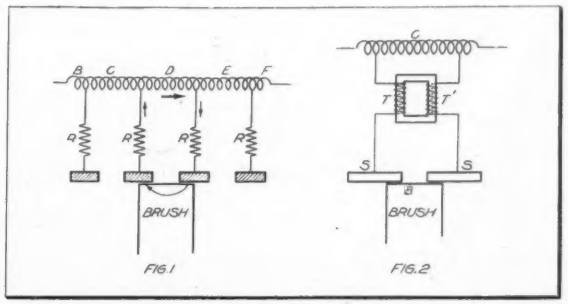


FIG. 1. RESISTANCES INSERTED IN COMMUTATOR LEADS
FIG. 2. BALANCED CHOKE COIL

armature section, D, short-circuited by a brush, and the heavy arrow represents the electromotive force induced in the section D by the pulsating field flux. The short-circuit current must flow through 2 resistances in series, as shown by the short arrows, whereas the useful current which enters or leaves the armature through the brush must flow through 2 resistances in parallel. When the brush touches but one commutator bar, there is no short circuit, and all of the useful current must flow through one of the resistances, R. It will be noted

that the resistances, R, are entirely idle except at the moments when the bars to which they are connected pass under a brush.

Resistance leads are objectionable because they involve a loss of power, and also for the reason that it is hard to find room for them in a compact armature. While a motor is in operation, each lead is connected into circuit in rapid succession, with the result that although the lead may become warm, the heat will be evenly distributed; in starting, however, there is the possibility that the motor may become stuck and a given lead be held in circuit for some time. In view of this possibility, it is necessary to make the resistance leads of large current-carrying capacity, and so to place them that they may be readily replaced in case of a burn-out.

To do away with the use of resistance leads, balanced choke coils have been used in their place. The essential feature of the choke-coil arrangement may be seen in Fig. 2, in which C is a section of the armature winding, SS are 2 commutator bars, and T T^1 are 2 choke coils through which the commutator leads pass.

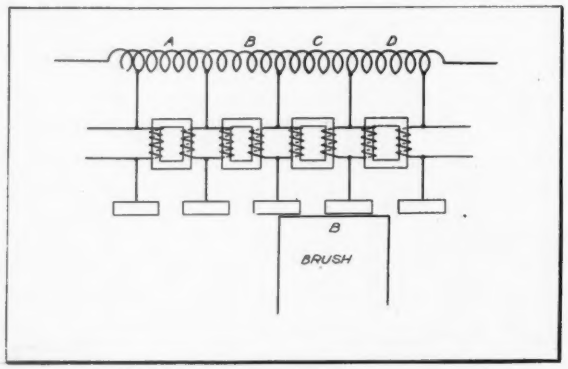


FIG. 3. COMPLETE ARRANGEMENT OF BALANCED CHOKE COILS

The 2 coils, T T^1, are wound on a small iron core and are so connected that their magnetizing actions on their iron core are equal and opposite when equal currents flow into (or out of) the armature winding through both coils; whereas their magnetizing actions work together when current tends to flow out of the armature winding through one coil and into the armature winding through the other coil. As a consequence the current can flow into or out of the armature through both of the coils T T^1 without being choked, while opposite currents in the coils T and T^1 (the short-circuit current in the section) are greatly choked.

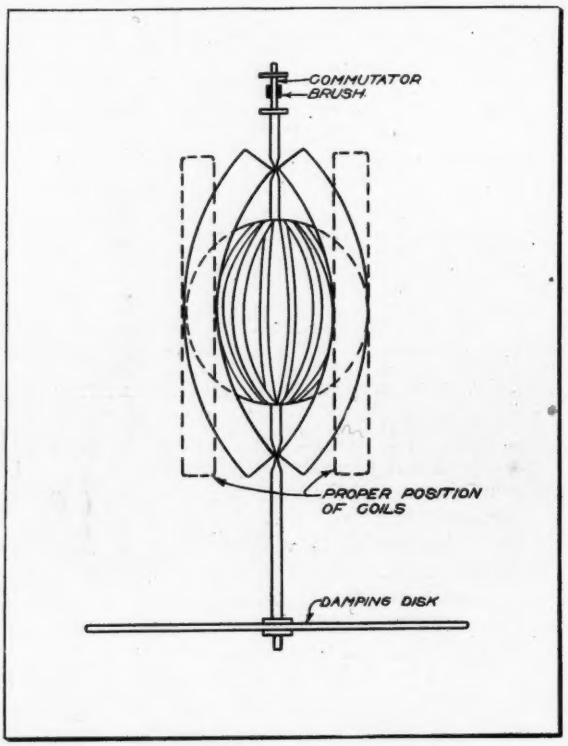
Complete arrangement of the balanced choke coils is shown in Fig. 3. Each commutator lead is split into 2 branches and each branch contains a choke coil which is balanced against another choke coil in an adjacent commutator lead. With this arrangement a brush must never touch less than 2 commutator bars because of the excessive choking of useful current when it has to enter the armature through the 2 choke coils in one lead. If the brush never touches less than 2 bars, it must at certain instants touch 3 bars, and when this occurs, a short circuit is established which is unchoked except by the combined ohmic resistance of 4 of the choke coils in series.

Result of a Short Circuit

By Meter Tester

While employed as a meter inspector by a Wisconsin public service company, the writer had an experience which undoubtedly may be of some interest to the readers of Practical Engineer.

A 10-amp., 550-v., direct-current commutator type of watt-hour meter was to be tested and for the purpose of creating a load, a water rheostat was employed. This water rheostat consisted of a small barrel having on its bottom an iron plate connected to the load side of the meter under test and in order to control the flow of current, the other plate, which was connected to the other load terminal of the meter, was suspended by a sufficiently strong cord passed over a small pulley fastened to the ceiling.



DAMAGED WATT-HOUR METER

After having determined the extent of error of the meter at both light and heavy loads, the proper adjustments were made and just as the load was again to be applied, the supporting cord broke, dropping the upper plate onto the lower one with a consequent short circuit.

The fuses had blown, but all too late. After the smoke passed away, the field coils were found in the position shown; that is, they had, by the momentary heavy magnetic field caused by the great rush of current, been torn from their supports and the ends of the coils bent over. In doing so, the 2 coils crushed the light, hollow aluminum shaft as flat as a piece of cardboard and in general, damaged themselves and the armature beyond repair.

Classification-Yard Lighting

ARRANGEMENT OF OUTDOOR LIGHTING, REDUCING OPERATING COSTS AND INCREASING EFFICIENCY

OF the greatest importance in freight handling, but little known to the general public, because of its infrequent contact therewith, is the classification yard, the function of which is the collection of freight cars into trains for specific destinations or routes. After the train has been made up with its proper quota of cars, it proceeds to the receiving yard where it waits until opportunity is afforded for it to pass out over the scales and be weighed, and proceed thence on its route.

The lighting of an area such as is presented by this class of yard affords some unique problems, the successful solution of which greatly facilitates the movement of freight traffic. The yard is not be considered as an open area but, in reality, as a series of streets 3 or 4 ft. wide, with buildings (freight cars) about 14 ft. high, on both sides.

FIG. 1. CLASSIFICATION YARDS OF THE P. & L. E. R. R. AT PITTSBURGH, PA.

One of the most effective installations of lighting in a classification yard recently made is that of the Pittsburgh & Lake Erie Railroad at McKees Rocks, just outside the city limits of Pittsburgh, Pa. This yard contains about 20 tracks extending for approximately ½ mi.

The source of light is the Cooper Hewitt Quartz lamp, mounted on steel towers, as shown in the accompanying illustration. The installation consists of 8 units, the lamps being rated at 2400 c.p., with an energy consumption of 726 w., resulting in an efficiency of 0.3 w. per candle. Direct current at 220 v. is supplied to the lamps from the power plant of the company located nearby. The towers, which are 12 ft. square at the base, are 100 ft. high and are spaced about 400 ft., in 2 rows, one on each side of the yard, or approximately 225 ft. across. The lamp is suspended from a short mast arm which extends out over a platform for the attendant, access to which is had by means of a ladder mounted on the side of the tower.

A chain and a cutout, however, permit the lamp to be lowered to the ground, thus obviating the necessity for the lamp attendant climbing the tower.

As the Quartz burners have a life of several thousand hours, and the globes are at such a height as to be out of the smoke zone, almost no cleaning or other attention is required.

The light given by the lamps spaced as they are, completely floods the yards, enabling the men to see with proper clearness, not only every track and car, but also the switches at the head of the yard. The illumination is such that one may readily read a newspaper at night.

In addition to the increased speed in handling cars gained through the better lighting, conditions are made much easier for the men returning afoot to the head of the yard, as when the yard is poorly lighted, it is difficult for them to avoid incoming cars, switches, posts and other obstacles, and the Pittsburgh and Lake Erie employes are particularly pleased with this feature.

The fact that the lamps are mounted at such a height permits an excellent distribution of the light, which possesses an inherent color value that is particularly suitable for outdoor illumination.

Another feature that peculiarly adapts the Quartz lamp to this field of lighting is the steadiness of the light, other forms of illuminants having repeatedly proved unsatisfactory because of the unsteady light emitted, which was not conducive to good work.

Afraid

BY N. G. NEAR

I MET a power plant salesman the other day and we chatted for a few moments. We talked about the relation between owners and engineers in the power plant field. Here are some of the important things this salesman said:

"I called on the owner of a big power plant yesterday and tried to interest him in our product. I tried to show him how the installation of our machine would more than pay for itself in a single year. I talked to him right from the heart, and every word I said was true, but he did not take even a half interest. I could not make a dent in him. He casually remarked, after a time, 'Go and talk to Jones, the engineer. I am leaving all such matters to him.'

"Thereupon I called on Jones, and, from the very start I saw that my case was lost. I saw that Jones appreciated the value of our product. He had read about it, and had seen it in action in other power plants. But, I also saw that Jones would never recommend its use. He hemmed and hawed. He invented excuse after excuse, and, finally, I did the only thing there was to do with such a man as Jones—I left.

"Why won't he recommend our product? It's simply this: Jones is afraid of the owner. Jones is one of the engineers who is afraid he will lose his job every time a carload of coal comes in. He thinks that the owner thinks that even coal is not necessary and that he, Jones, is responsible for the high cost of coal. Jones is conscientious, yes, but it isn't the right kind of conscientiousness. He doesn't look at his job in the right light. What's worse, he is one of the kind that can never be taught."

GAS POWER APPARATUS

Producers, Engines and Industrial Applications

Steam As the Byproduct of Internal Combustion Engines

NEW PROCESS BY MEANS OF WHICH STEAM CAN BE GENERATED BY INTERNAL COMBUSTION ENGINES. BY J. B. MERIAM

IN any internal combustion engine of the water-cooled type there is a loss of heat units through the cylinder walls into the water jacket. The distribution of total heat is about as follows:

Effective work	27 per cent
Radiation	3 per cent
Exhaust losses	38 per cent
Water jacket loss	32 per cent
	100 per cent

The exhaust gases leave the cylinder when the engine is fully loaded, at about 1100 deg. F. It is safe to say that during the power stroke, the average temperature within the cylinder will be above 2000 deg. F.

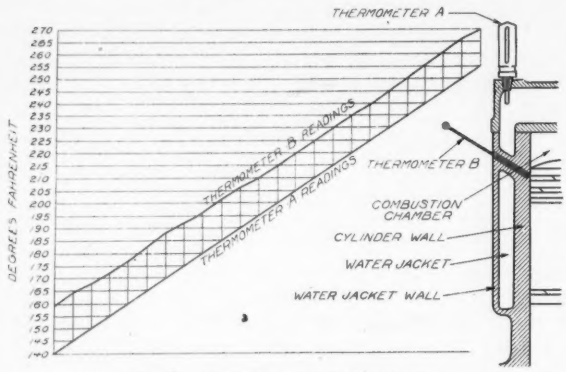


FIG. 1. TEMPERATURE GRADIENT

Heretofore, it has not been considered allowable to carry the temperatures of the water leaving the jackets of larger engines much above 150 deg. F. (which is hotter than can be borne with the hand).

Since difference in temperature is difference in heat potential, or tendency to flow, there should be no extreme difference in the flow of heat or cooling effect from the 2000 deg. within the cylinder to the water in the jacket, whether its temperature is 150 deg. or 250 deg. Other things being equal, the cooling effect is always directly proportional to the difference in absolute temperature.

With the figure assumed above, the ratio of cooling effect between carrying the engine jacket water at 150 deg. or at 250 deg. is as 100 is to 2463, or less than 5 per cent.

The fact, however, is that with ordinary water supply an engine will work satisfactorily at 150 deg., but if the temperature of the water in the jackets is allowed to rise, the cylinder or piston will burn or score before the jacket water reaches 250 deg. F.

The purpose of this article is to show that there is a reason for this seeming ill effect, and further that by the application of a certain process, this apparent ill effect becomes a valuable asset.

As an illustration of difference in temperature, consider that we have 2 houses at the foot of a mountain, one being located 100 ft. above the other and both supplied with water from a common reservoir 2000 ft. above. Now, if we had a good flow of water in the lower house, and but little in the one only 100 ft. above, we would at once conclude that the pipe was dammed up somewhere.

To find this similar stoppage or interference to the flow of heat in the case of the gas engine, we will refer to Fig. 1, which is a partial section of an internal combustion cylinder, showing the combustion space, the cylinder wall, the water jacket and the jacket wall. Let us first put down a clear statement of the elements which affect the flow of heat from the inside surface of the combustion chamber to and into the water. We have:

First—The difference in absolute temperature, or the relation of the 2 temperatures to the absolute zero point.

Second—The amount of surface exposed.

Third—The time of the exposure.

Fourth—The unit of resistance to the flow of heat.

Analyzing these causes, in the order stated, we find that the difference in absolute temperature is measurable, but as shown by the illustration of the water pressure in the houses, is not sufficient to cause the disastrous interference to the flow of heat which takes place somewhere between the surface of the combustion chamber and the water. The amount of surface is an important consideration in engine design, but after the engine is built it becomes a constant; that is, the amount of surface does not change, whether the temperature is 150 deg. or 250 deg. Similarly with the third element, after the revolutions of the engine have been determined, the time of exposure of the cylinder walls to the hot gases becomes a constant. In none of these 3 elements, then, do we find a reason for any disastrous change in cooling effect between using water at 150 deg. or 250 deg.

We must then consider the fourth element, with the full conviction that there must be some critical change in the resistance to the flow of heat as the temperature of the water is allowed to rise above 150 deg.

If we take an ordinary iron kettle containing water and a thermometer, and build a fire under it, it will be found that no visible change in the water has taken place below 140 deg. F., but that above 150 deg., there occurs (what we have all often observed) the formation of small bubbles which adhere to the surface of the iron. It will be further observed that these adhering bubbles increase both in number and in size with rise in temperature, and that by the time the water has reached 200 deg., the inside surface of the kettle seems fully covered with bubbles.

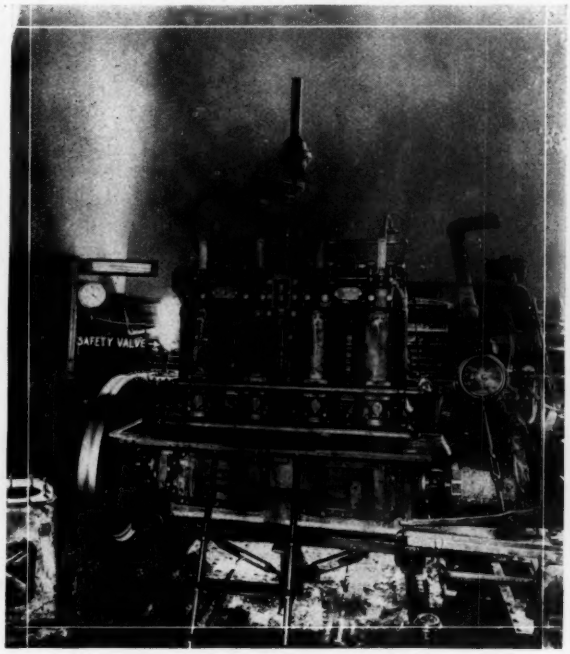


FIG. 2. 150-HP. BRUCE-MACBETH ENGINE UPON WHICH EXPERIMENTS WERE PERFORMED

Here lies the secret of the entire proposition. By closer inspection it will be seen that each bubble spreads out into a broad base at the point where it comes in touch with the iron surface. It is plainly evident that wherever there is a bubble adhering, the water is not in contact with the iron and that the bubbles act as an insulator.

Each of these bubbles increases in size, and finally breaks away at the neck, and a new bubble rapidly forms on the same spot, which is somewhat hotter than the metal surrounding it, which has been in contact with the water. If we stir the water in the kettle so as to put it in motion, we find that the bubbles break off while much smaller. In short, we find that the size of these bubbles decreases as the velocity of the water is made to increase.

Similar formation and adherence of bubbles takes place within the cylinder jacket of the internal combustion engine and constitutes a critical interference to the flow of heat or cooling effect of the water, and the resulting disastrous rise of temperature on the inside surface of the cylinder.

A series of experiments and tests were made on a 150-hp. engine, shown in Fig. 2, and the results were most extraordinary. The engine, which was a 4-cylinder, 12¼ by 14-in. Bruce-Macbeth pattern, was fully equipped with thermometers, flow meters and gages. A centrifugal pump (Fig. 3), was used to force the water at high velocity through the cylinder jackets, from which it passed into an enclosed tank which was in turn connected to the suction side of the centrifugal pump. The velocity of the water is maintained at from 5 to 10 times that ordinarily used.

It is considered important to know the relative effect of the high temperature jacket water upon the temperature of the metal close to the inside wall of the cylinder. For this reason, a cylinder was provided with a boss as shown in Fig. 1, and a 5/16-in. hole was drilled at an angle to within about 1/16 in. of the inner surface.

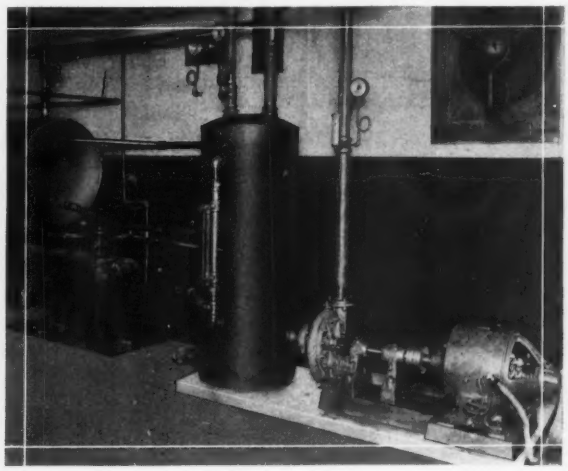


FIG. 3. INSTALLATION OF MERIAM STEAM PROCESS AT YOUNGLOVE BLDG., CLEVELAND

A drop of mercury was placed in this hole and a thermometer (B) inserted. A second thermometer (A) was then placed in the jacket water as shown.

It is desired that the temperatures of the inner surface of the cylinder wall, as recorded by thermometer B should not exceed those common in steam practice.

It is reasonable to expect that if the heat was carried away by the water as fast as it passes through the iron of the cylinder wall, then the difference in temperature of thermometers A and B (Fig. 1) should remain practically constant. This is fully borne out by simultaneous comparative readings taken at intervals of 5 deg., and clearly shown in the temperature curve.

With the particular engine and apparatus used in the test it was found to require a little less than 30 min. to bring the system up to 10 lb. steam pressure. In after tests the pressures have been increased to 50 lb., which is equivalent to a temperature of 297 deg. It must naturally follow that if an enclosed cooling system is used, and only steam is allowed to escape, then all of the water used must eventually be turned into steam, and the entire 32 per cent of the total heat units of the fuel referred to as lost to the water jackets is fully

recovered in the heat units restored to the steam. Careful calculation of the results shows this to be exactly the case.

With a well designed exhaust gas boiler, ½ of the 38 per cent of the total heat units of the fuel lost to the exhaust can be recovered and added to the 32 per cent recovered from the water jacket, which will give approximately 50 per cent of the total B.t.u. of the fuel available in the form of low pressure steam. It is interesting to note that the exhaust boiler or in fact any low pressure or heating boiler, located close to the engine, can be included as a part of the system. The engine on which the tests were conducted, was equipped with a water jacketed exhaust manifold, but without a specially designed exhaust gas boiler, and it was found that the temperature of the exhaust gases leaving the engine beyond the water jacket manifold exceeded at full load 950 deg. F.

Even with an engine of high efficiency and operating at maximum load, there will be evaporated by this process approximately 4 lb. of water into steam at 25 lb. pressure for each brake-horsepower-hour delivered by the engine.

As might be expected, the quantity of steam generated per brake-horsepower-hour increases as the load decreases. This is due to the fact that the engine under these conditions has a lower thermal efficiency and the fuel consumption per brake-horsepower-hour is therefore greater. On these tests it was found that at ¼ load the evaporation was 7.3 lb. of water per brake-horsepower-hour.

No difficulties or detrimental effects are experienced when operating the engine under this process at maximum load, and with the jackets under full steam pressure and temperature. On the contrary, the resulting condition is most favorable, since the water passes through the cylinder at such high velocity and in such large volume that the difference in temperature between the entering and outgoing water is less than 15 deg., and the cylinder and all the parts of the engine are maintained at uniform temperature. It is interesting to note also that this temperature remains constant irrespective of the load, as it is determined wholly by the steam pressure carried on the system. It is believed by the writer that this fact will prove of great value in overcoming the difficulties on large engines from expansion and contraction due to changes in temperature.

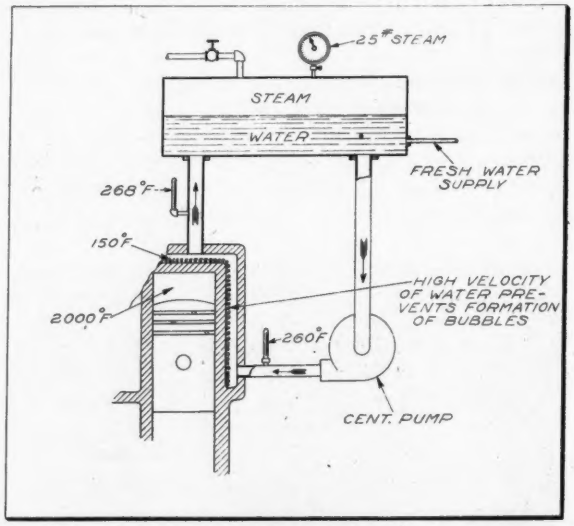


FIG. 4. PRINCIPLE OF THE MERIAM STEAM PROCESS IN OUTLINE

Another marked advantage in this process is found in the fact that the thermal efficiency of the engine is improved so that the fuel consumed is at least 2 per cent less at maximum load, and fully 15 per cent less at ¼ load. Even where the steam generated has no value, the process still pays well for its installation in the 2 items of improved efficiency and saving in water costs.

The large quantity of steam produced by this process is available not only for heating during the colder months, but for many kinds of industrial service where otherwise a special boiler or supply of steam would be required.

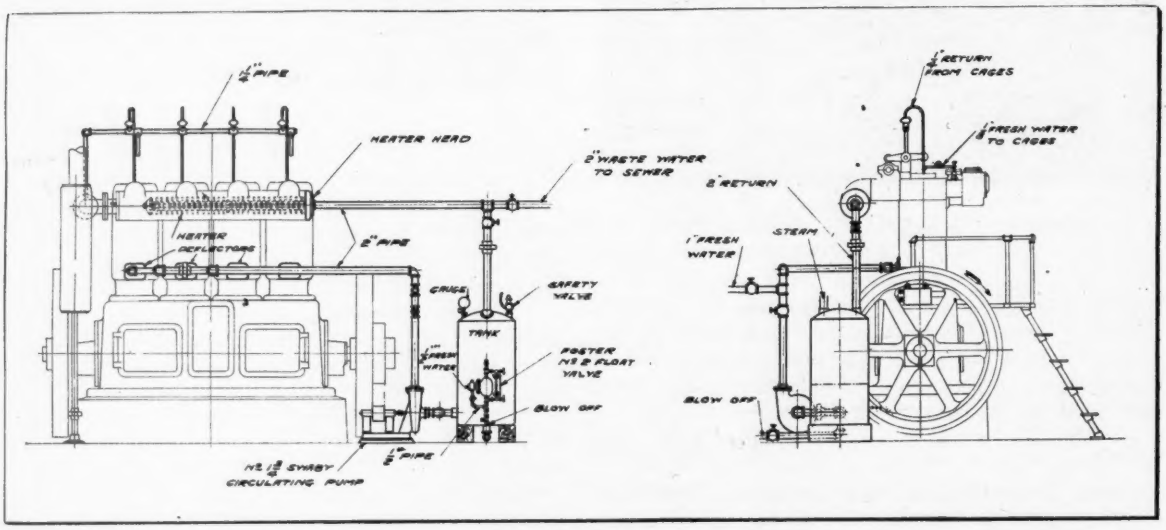


FIG. 5. PIPING PLAN FOR MERIAM STEAM PROCESS

Plants already installed are supplying steam for steam jacketing the wax pots of shoe factories, steam coils in drying rooms, hotel hot water supply, nickel plating baths, etc. This process has been in service on one engine of 150 hp. for a period exceeding 8 months.

Figure 3 shows the process as installed for the Younglove Building, Cleveland, where there are 3 gas engines of 150, 60 and 30 hp. each. The one motor-driven centrifugal pump supplies the high velocity water to any or all engines and but one expansion tank is used. The horizontal tank shown in the photograph is the hot water supply for the building, and is fitted with a steam coil which receives its supply from the process or from the low pressure heating boiler in the next room. This allows the hot water tank to be carried at full city pressure while the jackets of the engines are submitted to low steam pressures only—in this particular case, from 5 to 10 lb.

A 1¼-in. pipe connects the bottom of the process tank with the bottom of the heating boiler in the next room, the water level in both remaining the same.

The process is applicable to every form of internal combustion engine, whether operating upon natural gas, artificial gas, producer gas or oil, and has been developed by the Bruce-Macbeth Engine Co., Cleveland, O.

Gasteam Engine

Combination Used to Obtain Gas-Engine Economy and Steam-Engine Reliability

MUCH interest is being shown and many questions asked by people engaged in the various engineering lines in reference to the new power plant being built by the Ford Motor Co., for its Highland Park, Detroit, Mich., plant. This power plant throughout will be, without doubt, the most economical and efficient plant ever constructed. Not only efficiency and economy have been given consideration, but the plant is also designed to embody reliability to the greatest extent possible.

The plant will be a combination gas and steam plant, equipped with steam boilers, gas producers and "regenerators" as a producing medium for developing power.

The Hooven, Owens, Rentschler Co., of Hamilton, Ohio, is building the prime movers, which are a combination steam and gas unit, and which have been given the name of "gasteam" engine by the builders. There will be 4 units, and without a doubt one of the most novel prime movers ever attempted.

Each engine will consist of a 2-cylinder gas engine with cylinders arranged in tandem and also a tandem compound condensing steam engine. These 2 different types of engines will be connected to one shaft similar to the arrangement employed in a cross compound steam engine. Electric power will be developed by direct-connecting on engine shaft a generator of 3750-kw. capacity. Each engine will be capable of developing 6000 b.hp.

This combination engine will give the economy of a gas engine and the reliability of a steam engine, which answers the often asked question, "Why a combination unit, instead of a straight gas engine?" All gas engines when operating at their best, which is with full and constant load, are only then able to maintain a correct heat balance throughout the cycle. If, however, gas engines are operated in this manner, they have no overload capacity, resulting in the practice to run them underloaded. This produces wire-drawing of the gases through the valves and the ports, which has a tendency to precipitate tarry matters, etc., that usually do not give any trouble under full load conditions. With the combination type of unit, the steam engine is not supposed to be put in service unless there is a half load or more, hence the gas side will always be fully loaded. There has been no attempt made to govern the gas side, other than in case of over speeding. The steam side will do all the governing and take care of all load fluctuations. In case of trouble on the gas side, the steam side can pull the entire load with a late steam cutoff.

The 2 gas cylinders of the engine will be of the 4-cycle, double-acting type with water cooling. Each cylinder will be 42 in. diameter and will have a stroke of 72 in.

The tandem compound condensing steam unit will have a high-pressure cylinder 36 in. diameter and a low-pressure cylinder 68 in. diameter and having a stroke of 72 in. The low-pressure cylinder will be connected to a surface condenser which in turn will be placed in a closed heating system. The vacuum will be regulated to correspond to atmospheric temperatures and during the winter months, the vacuum will be reduced to about 18 in. and the entire amount of circulating water will be pumped through all the factory buildings which are heated by hot water. Superheated steam will be used with a pressure of 175 lb. and the high-pressure cylinder will be equipped with poppet valves, while Corliss valves will be employed on the low-pressure cylinder.

The attempt to absorb all the injected heat from the gas side or as much as is possible, it is believed will give gas engine economy with steam engine reliability, and this is being sought with this type of engine. Exhaust from the gas engine will be conducted into a steam superheater located in the steam line between the high and low-pressure steam cylinders, thus utilizing exhaust steam. Part of the exhaust waste gases for reheating the high pressure are shunted through the jacket of the high-pressure steam cylinder, which will in turn eliminate any steam heat loss in that cylinder. The exhaust gases are then conducted to the boiler feed water heater and will heat all the feed water required for the steam boilers.

Feed water for the heater is secured from the water used for cooling purposes in the gas cylinder jacket, where it is brought up to a temperature of from 150 to 180 deg. F. This is finally raised to a temperature of about 250 deg. F. in the heater by means of the exhaust gases.

As stated before, this installation will be, beyond a doubt, the most unique ever attempted, but is being based on the result of operation of a gas engine installed by the Ford people some time ago. This unit was of 6000 hp. capacity, and was built by the same company. No doubt all engaged and interested in the engineering profession will watch this installation with keen interest in order to ascertain just what results are being derived.—The Gas Engine.

EVERY BIT of energy bought as coal and put into the furnace comes out somewhere, either as work or as waste.

LETTERS DIRECT FROM THE PLANT

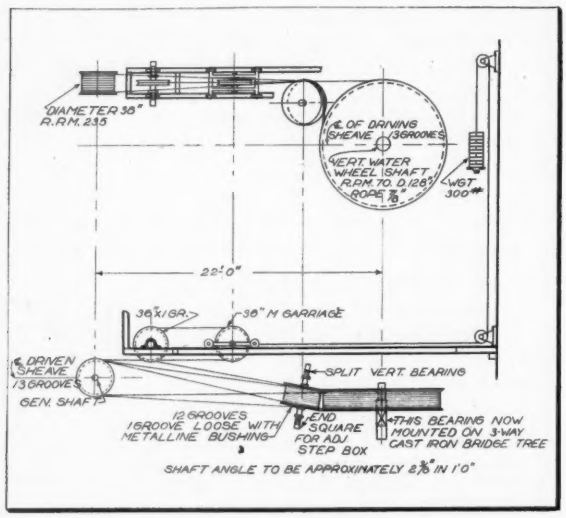
Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

Rope Drives

IN READING over Mr. Benefiel's article on page 889, Sept. 1 issue, one might conclude that the rope drive as a power transmitter has a narrow field, when the opposite is the case.

If a change of speed or load would cause the rope to jump the sheave, how is it that rope drives are used in electrical work, where a circuit breaker coming out changes the load from peak to friction in the smallest part of a second?

When our rope drive was installed we thought that any good belt dressing was all right; but, if one stops to think, what is good for a belt, which belongs to the animal kingdom, may not be good medicine for a rope,


DIAMETER 36"
R.P.M. 235
℄ OF DRIVING SHEAVE 3 GROOVES
VERT. WATER WHEEL SHAFT R.P.M. TO O.128
ROPE 7/8"
WGT. 300#
22'-0"
36"x 8 R.
36" M CARRIAGE
℄ DRIVEN SHEAVE 13 GROOVES
GEN. SHAFT
SPLIT VERT. BEARING
12 GROOVES 1 GROOVE LOOSE WITH METALLINE BUSHING
END SQUARE FOR ADJ. STEP BOX
THIS BEARING NOW MOUNTED ON 3-WAY CAST IRON BRIDGE TREE
SHAFT ANGLE TO BE APPROXIMATELY 2 3/8" IN 1'0"

ROPE GENERATOR DRIVE

which belongs to the vegetable kingdom. So we let the people who supplied the rope supply the rope filling.

Our drive is, as shown by the illustration, a water wheel driving a generator from vertical to horizontal and is situated about half a mile from the mill. A man greases it up 3 times every 24 hr. and the rest of the time it is alone. We have had 2 wrecks which somewhat mixed things up, but that was before we changed from belt dressing to rope filling; also, we found out that our idler was 3/8 in. out of line and that a little more weight was needed on the tension. When the rope broke on these 2 occasions, of course the water wheel kept going, and as it has no governor it was bad for the wheel; so our chief rigged up a trigger, and if anything on the driving wheel swings outside of its proper circle it hits the trigger, releasing a weight which, in falling, closes the gate and stops the wheel.

Here are a few guesses of my own: that a rope drive that has the proper tension and the sheaves of which are in line will not jump; that a rope which is a good rope and gets the proper filling and enough of it will not show wear on the outside; but that the core will crush after a long period of usefulness.

JOHN H. ARMSTRONG.

Peculiar Switch Accident

I HAD to install and work a new shunt-wound motor for a centrifugal pump to raise water from the ground floor to the third story of a building. After making the necessary wiring, I tried to start the motor, which, after giving some trouble (owing to some defects in making

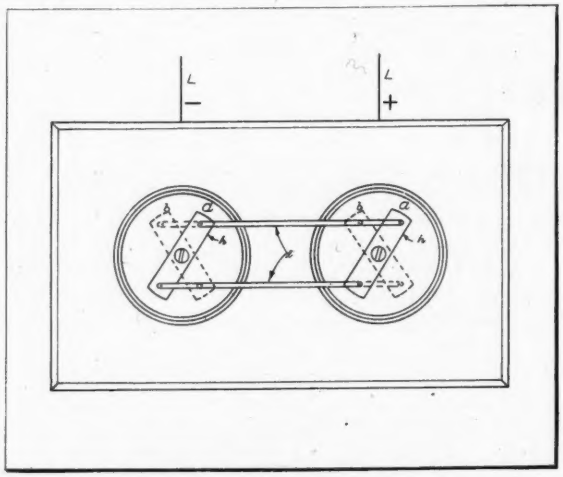


FIG. 1. SWITCH SHOWING "ON" POSITION WHILE AT A AND "OFF" POSITION WHILE AT B

connections of the motor starter and mains, which were remedied soon), started well. After working a few minutes, the switch was put off for a while; and when the switch was again put on, the motor did not start at all, which was quite a mystery.

To find out the defect, the mains were tested by touching 2 terminals of an incandescent lamp at L, L, Fig. 1, above the switch, the lamp burned all right; so, it proved that the current was in the lines; the connections of fuse and switch were also good. A double-pole switch, as shown in plan in Fig. 1, was used.

While trying to find out the defect, we took out the covers of the switch, and after disconnecting the 2 handles, h, from connecting rods, l, I tried to close the circuit one by one, with one handle. Then it was found out

that the slot, B, which fits into the pin, A, and turns the spindle of the switch, was broken, as shown by broken lines in Figs. 2 and 3; i.e., while putting the switch on (in the position at a, a in Fig. 1), it showed that the circuit was closed, but really it was not. (How the handle is fitted to turn the switch is shown in Figs. 2 and 3.) Only the handle moved from off to on position, i.e., from b to a; and that was the real cause of the motor not starting, because the circuit was not closed. When the circuit was really closed by means of another handle, the motor started all right, and there was no further trouble.

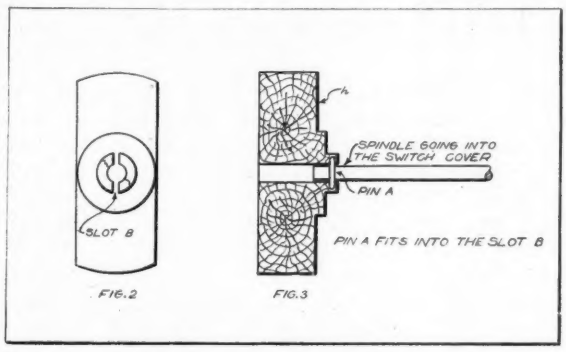


FIG. 2. PLAN OF EBONY HANDLE
FIG. 3. SECTION OF EBONY HANDLE

Of course, the defect was a simple one; but, being unusual, it was difficult to find it out. The switch used was an old one, and it is likely that the handle cracked long ago, and gave way at the time.

N. N. BAVA-ADAM.

Answers to Minnesota Examination Questions

FOLLOWING ARE the answers to the 50 examination questions appearing in Sept. 1, issue, page 887, as I would answer them before an inspector. Some of them, as, for instance, the first, are subject to many answers, depending on the experience of the applicant.

1. Subject to many answers.

2. They are brass plugs having a cone-shaped filling of pure tin, the larger end of the cone being on the pressure side. One end is hexagonal to receive a wrench. They are fitted with pipe threads.

3. Under normal conditions they are covered with water which absorbs the heat from them and they remain intact; when the water has dropped below them and the boiler is in danger, the heat of the fire melts the tin filling, which is blown out by the pressure inside, and the hole left serves as an outlet for the steam, notifying the fireman that the water is below the safe level, and also helps to relieve the boiler pressure.

4. In the center of the rear head not less than 2 in. above the tubes, and projecting through, the sheet not less than 1 in.

5. In the highest part of the crown sheet, projecting through the sheet not less than 1 in.

6. In the upper drum, over the first pass of the glass, not less than 6 in. above the bottom of the drum and projecting through the sheet not less than 1 in.

7. They should be inspected frequently to insure their condition and kept clean, both inside and out.

8. After emptying the boiler and removing the manhole and hand-hole plates, the boiler should receive a thorough washing out with a strong hose to remove all loose dirt. If the boiler contains much scale, some mechanical means must be employed for its removal. The bottom can be scraped with a long-handled scraper from the front end, unless there is a manhole under the tubes permitting the entrance of a person. The tubes should be cleaned with chains or scrapers made to insert between them. The heads may be cleaned with long chisel bars. If the boiler contains oil or grease, this should be scraped off as much as possible, the boiler filled with water to which is added enough soda-ash to make a strong solution and boiled a number of hours. Several gallons of kerosene thrown into the boiler before starting to fill it with water benefit greatly. This operation will also loosen the scale. After the boiler has been thus cleaned all the loose scale should be taken out and the boiler given another thorough washing with the hose.

9. No.

10 The front.

11. So it will draw back and out of the blowoff.

12. By covering it with some noncombustible material that can be removed for inspection of the pipe.

13. By setting the column containing the glass so that the lowest gage cock is at least 3½ in. above the top row of tubes. The bottom of the water glass is usually from ½ to 1 in. lower than the lowest gage cock. With the glass ½ in. lower than the gage cock, when water could just be seen in the glass there would be 3 in. over the tubes in the front end and 2 in. over the fusible plug in the rear end, providing the boiler has 1 in. pitch.

14. Water without circulation.

15. There is deficient steam space in the boiler for the work being done and the fast escaping steam is carrying the water upward with it.

16. Carry the water level lower, if possible with safety, if this cannot be done then the steam discharge must be checked to prevent water being carried over from the boiler.

17. The steam pressure per square inch on the boiler.

18. One registering too high.

19. The formula for finding the diameter is: $E = 0.3\ HP. \div \sqrt{H}$, or $D = 13.54\ \sqrt{E} + 4$, in which E is the effective area in sq. ft., HP. is horsepower of boiler, H is height of chimney in feet and D is diameter in inches.

20. The space should not be less than 1-6 of the area of the grate surface, and as much more as is possible to get.

21. There are numerous rules for finding the size of a safety valve. The Massachusetts rule is $A = (70\ W \div P) \times 11$ in which A = area of valve in square inches per square foot of grate surface. W is weight of water evaporated per square foot of grate surface per second. P is the absolute pressure per square inch at which the valve is set to blow.

22. Try all gage-cocks and open glass valves to be sure there is plenty of water in the boiler. This is also the proper time for blowing down.

23. Ascertain the source of supply water for the boiler, note in what condition the piping and means for putting it in the boiler are. Look for anything that might be a source of trouble at any time, and a possible remedy. Test the safety valves under pressure and see how the gages correspond with the valves and with each other. Examine the boiler settings and linings for any setting, the steam piping for pockets, note how it has been supported, what precaution has been taken for expansion and whether or not it is anchored. At the first opportunity, inspect the boilers for safety and clean liners. Then examine the engines, see that the governors worked well, get some idea of how the clearance is, see the kind of bearings and how much they are worn and if possible indicate the engine.

(To be continued.) A. G. LONGSTREET

An Air Lift Engineering Feat

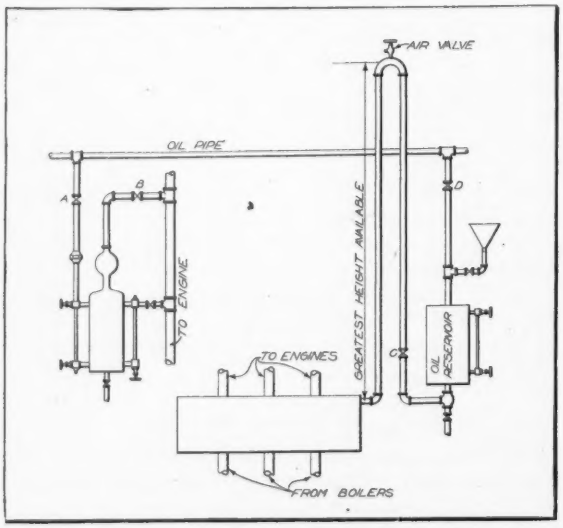
REFERRING TO the article, An Air Lift Engineering Feat, by Frank Richards, in the Oct. 1 issue, it may be interesting to know that while this plant was entirely successful in mechanical operation, it was found necessary to discontinue the pipe line service during the past summer on account of the effect of certain elements in the brine acting on the pipe, filling it with holes. During July, the plant was closed to visitors while chemists were at work making complete tests of the brine. The results of these tests, I believe, have not yet been made known.

RANSOM S. HAWLEY.

Trouble With Oiling System

IN REFERENCE to W. F.'s trouble with his oiling system, I should diagnose the case and prescribe as follows:

The solid lines in my sketch are identical with his sketch on page 1036 of the Oct. 15 issue.

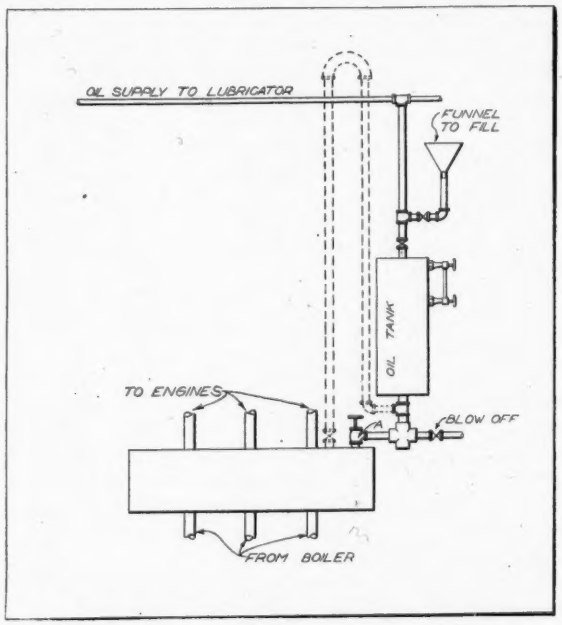


MR. MEINZER'S REMEDY FOR OILING SYSTEM

Where the tank is full of oil and valve A is opened, steam from the 28-in. header rushes in until the pressure in the tank is equal to that in the header. Under this condition, the flow of steam (or water) into the tank stops and the oil and water will work down into the header, instead of going up to the lubricator supply pipes, the same as the condensed water would return in a single pipe heating system.

If a loop is put in as shown by the dotted line and the original steam supply closed or disconnected, the system should work all right. The top of this loop should be 2 or 3 ft. at least, above the other points of the system.

When steam is admitted to this loop, which may be of ⅜ or ½-in. pipe, after equalizing the pressure between the header and tank it will condense and fill the bottom



MR. BOARDMAN'S REMEDY FOR OILING SYSTEM

of the loop nearest the bottom of the tank and as condensation continues, will float the oil, which is lighter than water, and cause it to flow to the lubricators through their respective supply pipes. In filling the lubricators, the water will have to be drawn off in the usual way.

CHAS. BOARDMAN.

RELATIVE TO W. F.'s trouble with an oiling system, I would say that he "spilled the beans" when he tapped for his pressure ½-in. angle valve from the top of the 28-in. receiver into the bottom of the oil tank through cross, where he drains the oil tank of condensation.

He will get "the answer" either by taking steam from some higher point, or by making a loop from the ½-in. angle valve, as he must have hydrostatic head to make that style of lubricator work at any time.

I would also suggest that he may experience trouble with his scheme of lubrication in the winter months unless his engine room has an exceptionally high temperature, as we all know that valve oil has a tendency to loaf on the job in the winter, and will want to linger in the oil lines like the proverbial molasses in January.

HARRY JOHNSTON.

W. F.'S TROUBLE is due to the fact that he has not provided sufficient head to his column of oil. Let him take a connection from the top of his steam receiver and carry it as high as conditions will permit, running it up an air shaft or side wall, put an air valve at the

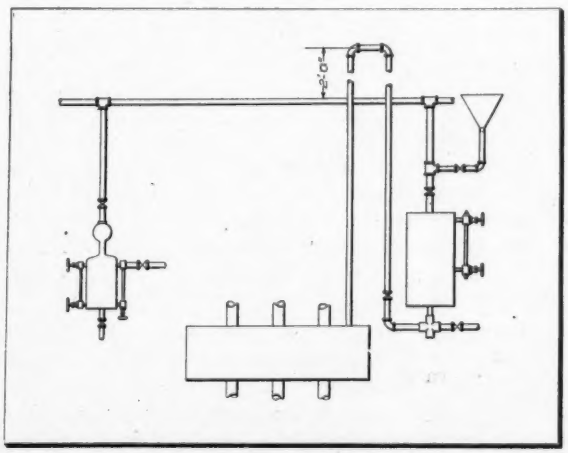
top, then come down into the bottom of his receiver and I will guarantee it will work. He will gain 1 lb. pressure for about each 2 ft. of height of his column to force the oil to his engines. The accompanying sketch shows how I would arrange it.

To operate this system, fill the oil reservoir and open valve C, allowing boiler pressure to come on the bottom of the oil. The steam in the pipe leading to the reservoir will condense and begin building up a pressure in excess of the boiler pressure due to the height of the column. Then open valves D and A and fill the lubricator by opening valve B until all water is driven out of the bottom of the lubricator, as will be shown by the glass at the side; close valve B and regulate the lubricator in the usual way. After this, it will be unnecessary to operate valve B, as no water will again get into the lubricator, unless it seems desirable to use the system for filling only. After filling, close valve A and open B, and when the lubricator is empty, repeat the filling process.

You will notice that I have not connected my filling pipe to the filling plug of the lubricator, but rather to the top of the oil glass fitting; this leaves the regular filling plug free to be used in case of any derangement of the system. The water that fills the lubricator is driven into the steam pipe on opening valve B when A is open. This system does away with the mess of dirty coffee pots for filling and old tomato cans for emptying lubricators, and is a source of comfort and pride to any good engineer. W. T. MEINZER.

Answers to Criticisms

I THINK the accompanying sketch will solve the trouble W. F. is having with his oiling system. The weight of water in the pipe from the receiver to the oil



ARRANGEMENT BY WHICH WEIGHT OF WATER WILL FORCE OIL THROUGH THE SYSTEM

tank will force the oil through the system. The pipe should be at least 2 ft. above the highest point of the system. WM. HOPKINS.

I HAVE just finished reading the criticism of my Catechism of the Corliss Engine, and I will state that it is not being published in its entirety, and the parts that are being published cover unusual conditions.

Considering F. M. Johnson's remarks, I will state that in my complete Catechism I explained the fact that the general construction was according to his description; but an engine was made and is sometimes met with that has a bar in the back, into which small holes are drilled and springs are inserted. This, I repeat, is not the general construction; but it is a possible construction, and in my Catechism the idea was to cover what might be met with.

In answer to the query concerning Question 5, I am drawing a possible valve construction Mr. Johnson has never met with. In regard to a fuller description of the gear being given, in the complete Catechism a full description is given, but the published parts cover the matter in a good general way.

As to Question 7, less than a year ago I had this very thing happen on a 36 by 36-in. Corliss, 60 r.p.m., and I can assure Mr. Johnson the engine stopped all right, and that with a boiler pressure of 115 lb. In my question, I did not consider an engine having a relief valve, which would of course relieve the high compression and allow the engine to pass the center; but, having seen this thing happen at least 4 times, I repeat that the engine will stop, provided nothing lets go.

Considering W. E. Dixon's criticism: In Question 4, I covered the generally accepted reason for having the exhaust valves at the bottom of the cylinder, and I was in no way considering the separation of the valves. If this question was the one at issue, I would ask, why not have the exhaust valve on the top of the cylinder and the steam valves at the bottom, where steam pipes come up through the flooring?

In Question 5, is described the old Harris Corliss gear; this gear is still met with and with slight improvements it is the gear still used on all slow-speed Corliss engines. To the engineering student, a good, clear understanding of this gear will cover all gears he may meet in practice; at least, that has been my experience. But, for Mr. Dixon's benefit, I will state that in my complete Catechism I took up other gears of later style.

In regard to Question 7, I can only refer to what I have already said in answer to F. W. Johnson.

Considering Question 16: It would seem that I am at fault; but in my work I was considering what Mr. Dixon terms "over travel," or the amount the valve overlaps when the dashpot is seated. This "over travel" can be adjusted by the dashpot rod, and I did not explain this as clearly as I might have. I believe this will explain to G. B. Longstreet, my unintentional error in Question 16. A. D. PALMER.

Corliss Engine Catechism; In Case of Accident to Boiler

IN THE Oct. 15 issue, I notice some criticisms of the Catechism of the Corliss Engine. I hope these will not deter Mr. Palmer from giving us some more.

In answer to Mr. Pierce and others as regards injured boilers and what one would do if he had no tools, the Massachusetts Boiler Inspection certificate states, in the last line, "In case of accident to a boiler, notify the boiler inspector at once."

Perhaps the examiner wanted to find out whether the applicant knew of this. P. F. M.

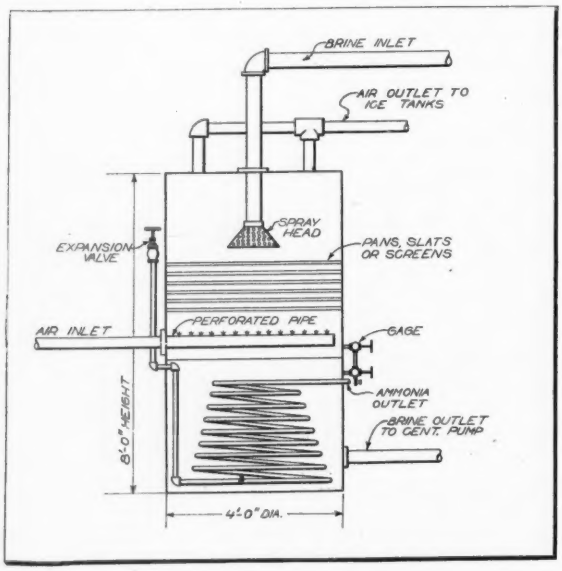
Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Refrigeration Problem

HEREWITH you will find a diagram of an air cooler and drier which I wish to try in our ice plant here, where we have the peat system and are now delivering air to the 4 tanks at a temperature of from 56 to 58 deg. F. I think this cooler and drier will cool the air to 14 or 16 deg. F. below freezing. We have a 140-ton tank, the daily output of which is 20 tons. How much do you think this will increase the daily output? I think that with this installed, we can freeze the same amount of ice in 5 days that now requires 7 days. What is your opinion? Please improve on it in any way that you can and do you think that the air pipes which are in the water in the tank will freeze and become inactive?

W. C. K.



AIR COOLER AND DRIER

A. We would not advise you to use cooler with brine spray, as the chances of the brine being carried over with the air to the ice tank would be too great; however, you could use the tank as shown, but with the ammonia coils left out. There are several plants equipped with such a cooling tank, the cooling being done with water direct from well or other source of supply. This water could be taken from a forecooler installed for this purpose, the cooling being done with the return gas from ice tank to compressor. Some manufacturers install a double-pipe cooler through which the air and water is passed; but never attempt to cool the air below the freezing point.

The amount that you might increase, or shorten the time of freezing, would depend upon the amount of air that is used for that purpose. As you did not state the number of cubic feet of free air used for the several tanks, we could not give you exact figures; but, assuming that you are using air at atmospheric temperature and that you should be able to cool it down to, say, from 90 to 50 in the summer time, you should make at least 1½ tons more ice per 24 hr. Should you care to give us the exact amount of free air used for agitation per minute in your tanks, we shall be glad to give you the exact increase you might expect.

W. H. BEISLEY.

Catechism of the Corliss Engine*

WHAT IS the range of cutoff in a double eccentric engine?

A. Full stroke.

55. What is meant by long and short range cutoff?

A. Long range cutoff is where the engine takes steam full stroke, and is still under the control of the governor; short range cutoff is where the cutoff must take place in some early part of the stroke, as in the single eccentric engine. If steam is taken full stroke in this latter case, the valves will not be under the control of the governor.

56. In what way is a single eccentric Corliss engine limited in regard to its horsepower and speed?

A. By its short range of cutoff. On the drop releasing gear, the speed is reduced by the fact that the steam valves must close before the exhaust valves open, and with this type of gear, the dashpot plungers may not seat quick enough to accomplish this.

57. How may this be overcome?

A. By a use of the nonreleasing gear.

58. Upon the side of most flyball governors, there is a device known as a gag-pot; what is its use?

A. In the gag-pot there is a small piston and with the governor in its highest position, the gag-pot under this piston is filled with oil. Now, in the case of the governor coming down, the gag-pot piston will go down and the oil will be forced to pass to the other side of the piston through a small opening in the piston. In some governors this opening in the gag-pot piston is controlled by a split screw, in some by an outside bypass, and in still another type the oil must be changed, a heavy oil giving a slow movement to the gag-pot and a lighter oil a quicker movement.

59. How may the speed of a Corliss engine be changed?

A. If the change is permanent, the pulleys that drive the governor and the governor pulley itself will

*Continued from page 1086, Nov. 1 issue.

have to be changed. If the change is only temporary, there are a number of methods employed, all leading to the same end—adding weight to the governor balls.

60. How may the steam valves be tested for leakage?

A. See that both steam valves are unhooked, or closed; crack the throttle, open indicator cocks and note whether the steam blows through.

61. If the valves are steam-tight, how may the piston be tested for leakage?

A. Close one steam valve and open the indicator cock on that end. Then open the steam valve on the other end and crack the throttle. If steam blows out of the indicator cock, the piston must leak.

62. How may exhaust valves be tested for leakage?

A. Disconnect both exhaust valves from the wrist-plate, and block them closed. Open both the steam valves and crack the throttle, and note whether the steam blows out the exhaust pipe. If the exhaust pipe is long, it may be necessary to disconnect it close to the engine. It is also well to remember that if steam enough is given the engine to cause it to roll over, it may blow out a gasket.

63. About what is the economy of the different types of Corliss engines when operating under good conditions?

A. Single cylinder—Noncondensing, 24 to 26 lb. steam per 1hp.; condensing, 19 to 21 lb. steam per 1 hp. Compound—Noncondensing, 19 to 21 lb. steam per 1 hp.; condensing, 14 to 16 lb. steam per 1 hp.

64. What are relief valves?

A. Relief valves may be considered as safety valves set in the cylinder to relieve the engine in the case of its getting water.

65. How would you determine the length of a new connecting rod, not having the old one to go by?

A. Move the crosshead to the striking points and make a mark for each end. Then place the crosshead exactly halfway between the 2 marks; by measuring the distance between the center of the crosshead and the center of the shaft, we get the length of the connecting rod. A. D. PALMER.

Pump Problem

I HAVE a duplex pump 5¾ by 6 in. stroke, making 80 double strokes per minute. How many gallons of water would be pumped in 12 hr. and at 60 double strokes for 12 hr.; no lift, but 45 ft. head pressure, allowing for slip? M. S. K.

A. The volume of each plunger displacement is equal to the area of the plunger times the length of the stroke, or, in the case of your pump, it would be equal to $5.75^2 \times 0.7854 \times 6$, or 155.76 cu. in.

As the pump operates at 80 double strokes per minute, and as there are 720 min. in 12 hr., the total plunger displacement of this pump within a period of 12 hr. would amount to 8,971,776 cu. in. As one gallon of water contains 231 cu. in., there would be delivered in this time $8,971,776 \div 231 = 38,838$ gal. of water.

If, however, this pump made only 60 double strokes per minute, as you have mentioned, the same method of calculation would be employed, except that the 60 would be substituted for the 80, and would result in a delivery of 29,129 gal.

Allowing 5 per cent for slippage, you will have, in the first case, a total delivery of 36,896.1 gal. per 12 hr., and in the second case, 27,672.55 gal. per 12 hr.

O. H. H.

Piston and Valve Leaks

How WOULD a diagram of a leaky piston and a leaky valve look? Please show by diagram.

2. What is the tensile strength of iron and steel rivets? A. P.

A. Where the piston of a steam engine alone leaks, the card will look about like Fig. 1.

In this, as soon as the supply of steam is cut off by the admission valve, part of it escapes past the piston into the opposite end of the cylinder, where it escapes through the open exhaust valve and the remainder of the steam in the operating end of the cylinder naturally forms the loop on the end of the card as shown.

Where steam leaks past the valve alone, instead of the expansion line dropping as in Fig. 1, it rises, owing to steam entering the operating end of the cylinder after cutoff has taken place, thus raising the terminal pressure as shown in Fig. 2.

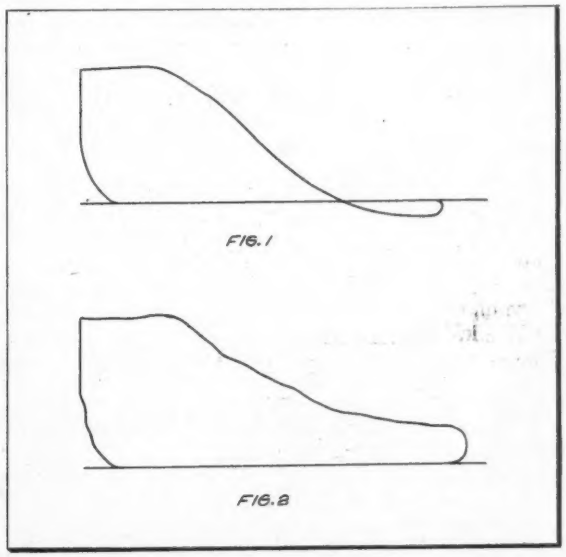


FIG. 1. LEAKY PISTON
FIG. 2. LEAKY VALVE

These cards are somewhat exaggerated for the purpose of illustration; but, while these 2 forms of leak are entirely opposed to each other as to action, it stands to reason that there is a point between them where the amount of steam leaking into the cylinder past the steam valve will just balance that which leaks out of it past the piston. While this is possible, it is hardly probable.

2. Tensile strength of rivets varies somewhat with the several grades, depending on the use to which they are put, ranging from 40,000 to 54,000 lb. per sq. in. of section; that of steel rivets is usually higher.

GEO. H. WALLACE.

Problems For Discussion By Readers

What Would You Do If You Had These Conditions To Meet?

Criticism of Corliss Engine Cards

REPLYING to J. M. S., page 1041, Oct. 15 issue, I do not think his card can be improved much if the engine now runs quietly. Personally, I would like to give it more compression and a little more lead. His voltage fluctuations are due to the swaying of the belt, probably on account of the flywheel being too light. If he can speed his engine up and change the pulley ratio, it will cure that. Or if the belt is laced, it may be due to the slipping of the laced part over the dynamo pulley, or to the laced part of some other belt in the mill.

W. T. MEINZER.

THE CARDS shown by J. M. S. are good, with the exception that the steam valves should have a little more lead, which may be given by adjusting the length of the steam rods. The steam line shows evidence of wiredrawing, perhaps due to the construction of the steam line, which he says has several elbows and 2 valves tending to cause considerable friction. The absence of a steam separator will increase the wiredrawing.

In order to get more information as to the cause of this trouble, I would suggest that he take steam pipe diagrams in connection with the cylinder diagrams in the manner described by Receiver in his article, Raising the Initial Pressure, in the same issue. The variation of voltage of from 2 to 5 volts each revolution is undoubtedly due to something else besides the valve setting, although a little earlier lead might be beneficial in this respect.

Electric generators, and especially alternators, require close speed regulation, and it may be that the engine was originally designed for mill work and the flywheel was not built as heavy as it would have been if intended for electrical work. Insufficient weight of wheel would cause unsteady action and consequently variation of voltage at each stroke of the engine. If this is the case, it cannot be easily changed.

Sometimes variation of speed is due to improper action in the governor. This cause of trouble can be remedied by thoroughly overhauling the governor. The belt or rope drive from the engine shaft may be too slack; the pins and bushings or gears may be badly worn, giving too much lost motion or the oil in the dashpot on the governor may not be of the proper density. If the proposition were up to me, I should first give the valves a little more lead on both ends, so that the card would make a good corner at this point, or possibly lean back a trifle, then examine the governor and clean out the dashpot and put in new oil. If this did no good, I would try different grades of oil in the dashpot until one was found that would give good regulation. If none of these things did any good, I would conclude that the trouble was in the flywheel, which could be cured only by putting on another wheel of greater weight.

J. C. HAWKINS.

Criticism of Answers

IN THE article entitled, Massachusetts Examination Questions and Answers, I find some good and practical questions, but to some of the answers given I do not agree.

It is, I believe, of the most importance that answers to such questions be given as true and to the point as possible in order not to mislead those who are looking for information.

In question 2, it is asked: If something happened to your engine and it was put out of order so it could not run, and you had no way of getting it on the center, how could you set the valve?

I take it from the question that the engine is a single slide valve and the eccentric has slipped.

In a case like that, I would advise, after taking the valve chest cover off, to turn the eccentric on the shaft until the valve shows the proper amount of lead, as if the engine was on the center (giving the lead to that end from which the piston has started last), and taking the angle formed by the position of the crank and the center line of the engine, I would turn the eccentric through the same angle in the direction the engine should run, when it would be set.

Question No. 7: Taking a new engine before setting up, how can you tell what the clearance will be?

This question, no doubt, means that the small parts of the engine are on the floor, such as piston, cylinder head, crank shaft, etc., and that we must find, by actual measurement, what the clearance will be; that is, the mechanical clearance and not the volumetric clearance, as the answer given would involve.

In this case, I would measure the length of the cylinder between the heads, substract from it the thickness of the piston, and divide the remainder by twice the length of the crank; dividing the quotient by 2 gives the clearance for each end. The correct answer to this question, I believe, is of the most importance in case there might have been any mistake made in the design of the piston.

Question 13: On a triple expansion engine, how would you find the terminal pressure of the low-pressure cylinder?

Here the answer given in the article is misleading, as it gives the number of expansions instead of the terminal pressure as wanted.

To find the terminal pressure in any engine, divide the absolute initial pressure by the number of expansions, and the quotient will be terminal pressure.

Question 14: If the fusible plug gives out, where would the water fall in the fire-box?

I presume this is understood to be a locomotive type of boiler. Now, it strikes me that if the fusible plug gives out in such a boiler, it will be when pretty well uncovered; that is, the water will be much below its upper end, and consequently nothing but steam will blow over the fire. X. N. TRICK.

What Is Wrong

REPLYING TO T. G., page 1041, Oct. 15 issue, without knowing what the Massachusetts rules for the installation of heating boilers are, I would say that there should be no valve under the siphon damper regulator, that the chain from door to regulator is evidently disconnected; that the connection taken from the pipe under the steam gage should not be allowed and that it does not look like a lock-up safety valve. Heating boilers should be fool-proof and the less valves, etc., on them the better they will be. I am even inclined to think that I would not put valves on the water gage glass. W. T. MEINZER.

IN REGARD to the cut on page 1041, Oct. 15 issue, the Massachusetts Boiler Rules are divided into 3 parts. Part 2 of the rules applies to all boilers now or hereafter installed.

Referring to Part 2, Section 2, Paragraph 13, we find: "Each boiler shall have a steam gage connected to the steam space of the boiler by a siphon, or equivalent device, sufficiently large to fill the gage tube with water, and in such a manner that the steam gage cannot be shut off from the boiler except by a cock with T or lever handle, which shall be placed on the pipe near the steam gage."

The cut shows clearly that there is no shutoff cock between the boiler, and the steam gage, and a siphon of sufficient size to fill the gage tube with water is missing.

These are 2 points that are wrong according to the rules, and while 2 wrongs never make a right, they frequently make a third wrong. This is the case here, since an inspection certificate has evidently been issued contrary to the "Act relative to the Inspection of Steam Boilers, Commonwealth of Massachusetts Act of 1907." Quoting from section 15 of this act: "If the inspector finds that the boiler is not in safe working condition, or is not provided with fittings necessary to safety, or if fittings are improperly arranged, he shall withhold his certificate until the boiler and its fittings are put in a condition to insure safety of operation, etc. E. L. C.

Criticism of Corliss Engine Cards

H. E. S., IN Oct. 1 issue, page 986, submits 2 sets of indicator cards that are very interesting. He also asks for advice on what further changes he can make on the engine to better the running conditions.

It is quite evident from the cards marked Fig. 2, that the steam opening or steam admission is late, especially on the crank end. On the head end, the card shows that the steam is wire-drawn, as the full boiler pressure is not reached until nearly to the point of cutoff.

The wavy expansion line might be caused by steam leaking, by the steam valves, or it might be caused by a sticky indicator piston; but the former cause is the more probable condition, as the contour of the other lines on the card seem free from this waviness.

The release line shows that the cutoff is too early; in other words, the engine is not getting steam enough. To remedy this, adjust the cutoff or radial rods from the governor so as to get a later cutoff.

If the steam valve hook picks up the steam valve from the inside, that is, toward the wristplate, lengthen the radial rods; if from the outside, shorten the radial rods for a later cutoff.

To test the steam valves for leakage, place the wristplate on center and open both indicator cocks to the atmosphere; then open the throttle valve and if steam issues from either the head or crank end indicator cock, it shows that the valve on that end is leaking. If they both issue steam, it shows that both valves are leaking. In giving these instructions, I am assuming that the piston is steam tight.

The probabilities are that both steam valves are leaking somewhat. About the only remedy for this condition is to have the valve chambers rebored and a new set of steam valves to fit the rebored chamber.

C. E. ANDERSON.

H. E. S. ASKS FOR information in regard to the indicator diagram taken from his Lane and Bodley Corliss engine. Card No. 2, which was taken after the adjustments were made, shows all the events of the stroke to be late. The admission line slopes forward where it should be perpendicular, the release line shows that the exhaust valve does not open quick enough, the piston has to work against the retained exhaust steam during part of the stroke where the line should make a well rounded "toe," and the exhaust valves do not close for compression quite so early as they should. To remedy these faults, the eccentric should be advanced on the shaft, say ¼ in., as a trial; causing the several events to take place at an earlier point in the stroke. After advancing the eccentric it may be necessary to make a few slight changes in the valve rods to get both ends alike. The cutoff on the head end should be made earlier, as that end is doing more work than the crank end. This should be done by adjusting the knockoff cam rod on the head end. J. C. HAWKINS.

I NOTE in looking over the indicator cards submitted by H. E. S., that his engine is a single eccentric and looks as if it is also a single ported valve. And the exhaust valve may leak a little. His engine could stand a little more compression if he advances the eccentric about 3/16 in., lengthens the steam lap on H end and shortens it a little on C end, so it gets the proper amount of lead; then adjust the dashpot rod and I think it will be O. K. A. L. JOHNSON.

A GOOD RULE in regard to coal testing is to have a a test by calorimeter and approximate analysis of a sample taken from at least every 250 tons; oftener unless the source of the coal is known.

The Power Plant's Heart

From the Boiler Room Flows the Life Blood to Sustain All Other Organs

THE January 1st, 1915, number of Practical Engineer on "Modern Boilers and Boiler Room Practice" will treat this important division of the plant and its operation. Boiler room expenses exceed, many times, all other power plant expenses, and this number will point out to Engineers new economies and new principles, and show how they can be put into practice.

We are all fast coming to realize the fact, as the more modern plants have already realized, that the boiler room is worthy of the most careful consideration as to equipment and operation if we are to secure the best economy from the plant.

Coal is a messy commodity. It is not possible to attain in the boiler room where coal is used, the same immaculate conditions as in the engine room, but it is the place where most of the money is spent, and should receive corresponding attention. It is fitting, therefore, that the specialized issue for January 1st, 1915, should treat of the equipment in the boiler room and its care.

Laying the Foundation

BEGINNING at the bottom, the question of bearing power of soils, and the size and weight of foundations of different materials required for different soils will be considered, also the question of building ash pits of such shape as to reduce the labor of ash handling.

Then the question of suspending the boiler on the walls or separate framework, and the methods of suspending by brackets or saddles, and the adaptation of these methods for different types.

Next the walls and the question of material to use, the effect of air spaces, thickness of mortar, and the proper mixture, how to avoid and stop up cracks in the setting, the use of sheet metal covering, and proper location and shape of peek holes and clean-out doors.

Also, there will be discussion of firedoor arches, back arches, bridge walls, mixing piers, different types of fronts, ignition arches, and the use of different coverings for the steam drum, and with this will naturally be taken up the different materials, such as common brick, fire brick, baffle tile, plastic coverings, and the various special substances for furnaces.

For the Best Combustion

BESIDES the grate, it is necessary to have proper proportions of firebox and combustion spaces if the boiler is to be most economical. Therefore, the types of furnaces for different kinds of coal, and the relation of firebox and combustion space to boiler capacity, the amount of grate surface and heating for fire-tube and water-tube boilers, provision for gas passages when the boiler is to be forced, and the effect of circulation on boiler capacity will be treated.

The boiler must be strong as well as economical, and under the topic of Strength, will come the subjects of riveted joints, types, proportions, methods of figuring efficiency, the strength of the shell, methods of bracing for different types and conditions, including diagonal braces, angles, through braces, use of tee and angle iron, stay bolts, and the method of fastening braces to heads and shells.

Next, the arrangement of tubes, including the spacing for strength and for circulation, methods of fastening tubes and of retubing.

Then the methods of baffling in order to give the proper passage of gas across the tubes, particularly in the case of water-tube boilers, and the draft loss in the different parts of the gas passages with different methods of baffling, the draft which will be necessary through the fuel bed, through the tubes and in the breeching and uptake. Also the effect on the draft of leakage through the setting.

Safety and Clean Boilers

LOCATION and size of manholes and handholes will be considered, also methods of feeding the boiler, the place and direction for the feed line discharge, kind of discharge nozzle to be used, the use of steam baffles to prevent the passing of wet steam into the steam main, also the location, form and size of dry pipes and domes where used.

The safety valve will be taken up, including the construction of the pop and lever valve, how to regulate the blow-back, and the proper method of piping safety valves.

Also the purpose of the water column, its proper location and connections, the proper care,

use of high and low water alarms and feed water regulators, the proper placing of the gage glass and gage cocks.

Fusible plugs, proper shape and proper location for different kinds of boilers, and the different methods of arranging bottom and surface blowoffs, and of the piping and valves will be shown.

Superheated steam is now largely used, especially for turbine plants, and the location, size and handling of superheaters for different classes of work will be considered.

Firing Methods and Results

PASSING to the operation of boilers as distinct from the installation of equipment, the first and most important duty is that of firing. Different methods of hand-firing will be studied, with the results to be attained by each, and the best methods for different kinds of grates and different fuels.

Different types of stokers in common use will be taken up, and their action discussed, also the precautions which should be taken in firing to get the best results, including the depth of the fuel bed for different kinds of coals, effect of holes and clinkers, carrying the bed too thick or too thin, and the proper color of the flames.

Closely allied to the firing is the draft regulation, which includes the proper handling of dampers, fire-doors, ashpit doors, and will include, also, a discussion of the balanced system of draft, the use of heated air supply systems, steam jet systems for smoke reduction, and automatic systems of regulation, in accordance with the fuel burned.

Also, gas analysis to test whether the fire and draft regulations are correct, showing the method of taking sample gases, and the method of making analysis for the different components of the gas. In connection with this work, temperature readings are important to show the temperature drop through various parts of the combustion path, beginning with the atmosphere outside, then the boiler room, the combustion chamber, and the different points in the boiler setting, to find what parts of the boiler are doing the most work, and whether each part is doing what it should.

In order that the temperature may be right, and the draft secured with the best economy, the brick-work must be kept free from air leaks, and in this connection, the method of finding air leaks, and of stopping them up, also of keeping the ignition arch in shape, renewing fallen baffles and preventing clinker formation on the fire-brick will be treated.

Systems of soot and ash removal, and of keeping the tubes clean will also be discussed.

Measurements and Records

THE question of feeding the boiler has already been referred to, and in connection with this the recording of temperatures, of feed water in and out of the feed water heater, and in and out of the economizer will be taken up, and the cause and effect of temperature changes shown.

There will be a brief treatment of the analysis of feed water, use of compounds, hot and cold methods for softening, the use of chemicals, mechanical purification, and other methods of keeping boiler free of scale. Also, methods of measuring both coal and water to determine the evaporation per pound of coal, and the different kinds of apparatus used, including displacement meters, pump stroke counters, recording meters of the Venturi and notch type, and on the other end of the boiler, the use of steam flow meters to determine the output of the boiler, where they should be used, and how their readings can be made valuable.

Systematic Inspection and Repair

CLEANING and repairs are important if the boilers are to be kept up to the top-notch of efficiency. The frequency of cleaning, with detailed instructions from the time of shutting down to putting the boiler back in service, will be given, with suggestions for different kinds of boilers and the use of different methods of cleaning, including treatment to prevent necessity for cleaning.

Periodical inspection of boilers, testing of safety valves, blowing down, testing of plates and joints by hammer and hydraulic test, inspection of valves for leakage, and the inspection for corrosion and other deterioration will be fully given.

Emergency instructions for things likely to happen, such as bagged plates, burst tubes, fallen bridge walls, and for the putting on of hard and soft patches, replacing of tubes and plates, and repair of brick-work at different points as usually needed about a plant will be taken up in order.

The routine handling of a boiler plant by modern methods of management will be studied in the best modern plants, and the results of this study will be given to readers in this issue, showing just how the work is done and, so far as possible, the results which are attained.

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Too Busy to Advance

No doubt you know a great many engineers—good and bad, for there are good ones and there are bad ones. Have you ever met the kind that are too busy to advance? We will try to describe him whom we have in mind to see whether or not he measures up to the type you know.

This man, single-handed, operates 2 boilers and a 100-hp. noncondensing steam engine. Many years ago he was a helper, but was given complete charge when his boss, the former engineer, died.

His employers say he is a "wonder" and an "awfully hard worker." They raised his pay 15 yr. ago after he had proved beyond a shadow of a doubt that he could handle the whole job alone. And in getting him to do it all, and paying him the same wages his former boss had received, the employers thought they had driven an excellent bargain. To keep the plant going, he works day and night.

Talk to this man about superheaters, CO_2 recorders, or indicators, and he'll stare at you. He doesn't know what such things are for.

"Condensers," he says, "are no good because they don't take oil out of the water." Doubtless he heard his "old master" say that.

To him, efficiency has no meaning.

He chips the scale out of his boilers at night or on Sundays. He doesn't know that most of the scale can be precipitated outside of the boilers or prevented from adhering, and that coal can be saved in that way.

He has much trouble with his pump. Dirt particles get in and clog it. He knows no remedy save hard work to set the pump aright. In the old days, they didn't use strainers.

He knows nothing about oil and oiling systems. His methods are antediluvian. Everything is done by hand—by force. Intelligence is almost a zero quantity.

He does not want a helper for fear the helper would learn too quickly and displace him.

He always goes the long way 'round in making repairs because he knows no quick methods.

He orders and insists on old, out-of-date materials because he knows none better.

He doesn't associate with other engineers. He doesn't read an engineering paper. He hasn't time.

Fire

When did you have the last fire drill of your power plant force? Haven't time? Well, there'll be no time after the fire starts, yet every man will be needed right where he can do the most good. Nor will there be time to struggle with sticky valves, disconnected or leaky hose, nor to hunt up mislaid nozzles. Of course, fire protection may not be part of the power plant responsibility except so far as fire pump and connections to fire supply system are concerned, but the engineer is usually more closely in touch with the matter than anybody else, and if his end of the fire fighting system fails, either equipment or organization, it is likely to go hard with the rest. So that it is of more importance that the power house be shipshape as to prevention of fire starting there and prompt action when fire starts anywhere, than for any other part of the plant. If there is general fire drill, your part should be included. If

there isn't, it is more important than ever that every man in your force know where to go and what to do when the emergency comes, and that he have sufficient practice so that there is no doubt or hesitation about doing it. Once a month is a minimum for tryouts of men, and once a week for testing of apparatus.

Home Market

Emergency has driven the United States back on its own resources to supply its own needs. Whether we shall become the "factory for the world" or not will depend partly on the course of events that we cannot foresee; but certainly we may well develop our own industries, agricultural, mining and manufactures to the extent that stoppage of supply from foreign lands shall not disturb the supply of our necessities.

What can we each do to help? Few are in position to develop new supplies of raw material, or to establish new factories, but all can demand, so far as possible, when buying, goods made in the U. S. A. and from United States material. In other words, if every person helps to make our home markets as large and active as possible for our own goods, we shall take a long step towards economic independence. At the same time, we are making a more active and better paying market for labor and ability, which is what the great majority of us have to sell.

With few exceptions, United States goods are or can be made as good quality, and serviceable as those made anywhere else, and in those cases where the cost is slightly greater, the best interest of the country, of which our own best interest is part, warrants the outlay.

News Notes

SOCIETY FOR THE Promotion of Engineering Education is issuing a third edition of its Syllabus of Engineering Mathematics, which will soon be ready for distribution. The Council has decided to hold its 1915 meeting June 22 to 25, at the Iowa State College, Ames, Ia., which is particularly fitting in view of the fact that Dean Anson Marston, of the Iowa State College, is President of the Society.

UNITED STATES CIVIL SERVICE COMMISSION announces an examination for engineering inspector for oil and gas, to fill 4 vacancies in this position in the Department of the Interior, for service in Oklahoma, at salaries ranging from $2160 to $3300 a yr., and vacancies as they may occur in positions requiring similar qualifications. Duties will be to inspect oil and gas production on Indian lands, and advise the Indian Agency, operators, and owners of oil properties in connection with the drilling and operating of wells, with a view to preventing waste and overcoming difficulties due to high gas pressure, to caving formations, and to encroachment of underground waters; and in cases where such action is necessary, to take charge of and operate the drilling rigs to stop the flow of oil, gas or water in the most satisfactory manner. Competitors will not be assembled for examination, but will be rated on the following subjects, which will have the relative weights indicated: Education, 15; experience and fitness, 70; thesis, 15. At least 6 yr. practical experience in oil and gas well drilling and operation, including experience with high gas pressure, caving formations, and in cementing wells to exclude water, is a prerequisite for consideration for this position. Under the third subject, the thesis must present the result of the applicant's own work in the field of oil or gas production. Statements as to education, experience, and fitness are accepted subject to verification. Applicants must have reached their twenty-fifth but not their forty-fifth birthday on the date of the examination. Persons who desire this examination should at once apply for Forms 304 and 2095, giving the title, Engineering Inspector, Oil and Gas (Male), $2160-$3300, to the U. S. Civil Service Commission, Washington, D. C., or the secretary of the U. S. Civil Service Board, at any of the principal cities of the United States or its island possessions. No application will be accepted unless properly executed, excluding the medical certificate, and filed with the Commission at Washington, with the material required, prior to the hour of closing business on Dec. 1, 1914.

GERMANY HAS heretofore monopolized the market in Spain for electric wiring devices and supplies, and there is a fair stock in the hands of dealers, but if American manufacturers can arrange to supply material on the same basis that it has been supplied by the German manufacturers, namely, net prices delivered in Valencia, with reasonable credit, the business may be secured permanently.

The consulate at Valencia believes that permanent results can be obtained only by personal representation, and preferably by the establishment of a joint agency with sample room for devices in different lines.

Approximate retail prices at which goods must be sold run as follows:—Lamp sockets (bayonet type), 18 cents each; push buttons, 45 cents; wall switches, 27 cents; fuse boxes, 72 cents; cleats, per pair, 4 cents and upward, according to size; shade rollers, 10 cents each; glass shades, $1.08; metal and porcelain shades, 27 cents; metal filament lamps, 75 candlepower, 45 cents and less; the prices being for the better grades of German make of goods. A list of the leading dealers and large users of these devices may be obtained from the Bureau of Foreign and Domestic Commerce, Washington, D. C.

FRANK W. HALL, who has been associated with the Sprague organization for the past 19 yr., occupying various positions of responsibility in the engineering and commercial departments, has been appointed Sales Manager of the Sprague Electric Works, New York.

PLANS ARE BEING PREPARED for electric generating plants in 5 of the school buildings of Pittsburgh, Pa., as the Board of Education and the Allegheny County Light Co. are unable to agree about the rate that should be paid for current for light and power.

THREE OF the 5 2000-hp. units in the new power plant of the Northern Mississippi Power Co., an adjunct of the Minneapolis General Electric Co., were recently placed in operation.

This power station, which is located at Coon Rapids, 16 mi. north of Minneapolis, on the Mississippi River, was erected at a total cost of $1,500,000, and when completed will be capable of developing 14,000 hp. Due to the increasing demand for current, this plant was built and will be operated in parallel with the Riverside, Taylor's Falls and St. Anthony Falls stations.

Power Apparatus in Shop and Market

New Ideas In Making, Buying and Selling

Burd High Compression Rings

WITH the object of preventing the leakage of gases past the pistons of internal combustion engines, the Burd high compression ring has been designed.

As shown in the accompanying cut, these rings are of one thickness all the way around and therefore exert an equal pressure against the cylinder wall at every point. They are made of a special grade of gray iron to withstand heat and will glaze to a glass-like smoothness, when they will run almost indefinitely with little wear to themselves or the cylinders. Instead of being turned, these rings are ground, resulting in all the scale on the inside being retained with the consequent toughening of the iron to a remarkable degree.

BURD COMPRESSION RING, CLOSED AND OPEN

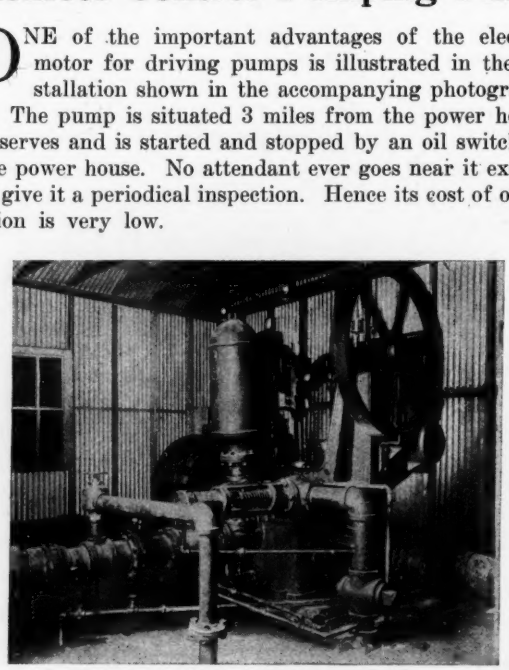
As shown, this ring is provided with a bronze coupler. By springing the ring open slightly, the coupler lifts out and the ring is ready to spring over the piston. The coupler is then placed into the ring before replacing the cylinder, when both the ring and coupler lock together. As an equal pressure is presented to the cylinder wall, no elliptical cylinders will come from their use. In this they are much superior to the eccentric ring which exerts its greatest pressure on its 2 sides due to the greater thickness at the back. As a single ring it can be ground accurately to fit the ring grooves. The coupler seals the opening to the passing of oil or gas as well as sealing the opening to the passing of oil or carbon into the air space between the ring and the piston which, with the ordinary ring, causes it soon to become stuck in the slot, at which time it ceases to perform the functions of a packing ring. Rings are dangerous that present openings through which this space behind them can fill up with carbon and oil that gradually bakes into a hard mass, cementing the ring firmly into the groove. Rings with a simple opening or openings on either side tend to collect carbon deposits on both the upward and downward strokes and should a ring of this kind resist clogging, its expansion causes it to open on opposite sides when, by gas passing through the air space back of the ring, it becomes little better than one of the ordinary type.

These rings are made by the Burd High Compression Ring Co., of Rockford, Ill.

Remote Control Pumping Plant

ONE of the important advantages of the electric motor for driving pumps is illustrated in the installation shown in the accompanying photograph.

The pump is situated 3 miles from the power house it serves and is started and stopped by an oil switch in the power house. No attendant ever goes near it except to give it a periodical inspection. Hence its cost of operation is very low.



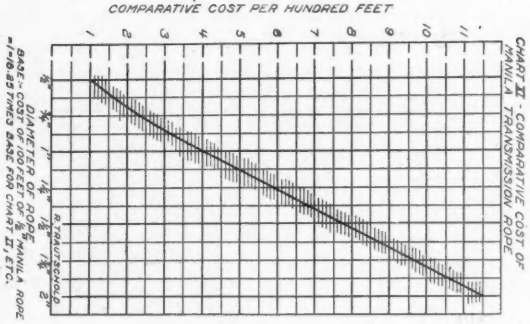
PUMPING OUTFIT OPERATED BY REMOTE CONTROL APPARATUS

If desired in such an installation, recording instruments can be placed in the power house to indicate how the pump is operating. Such instruments show whether the motor is running normally or not and if the load is too high or too low, thereby giving notice when something is wrong. The power house attendant can, therefore, give the outfit almost as careful attention as a man on the spot could give. It is convincing testimony as to the reliability of the motor-driven pump that such an outfit can be operated for years without trouble of any kind.

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

PRACTICAL ENGINEER


COMPARATIVE COST PER HUNDRED FEET
1 2 3 4 5 6 7 8 9 10 11
DIAMETER OF ROPE
R. TRAUTSCHOLD
BASE = COST OF 100 FEET OF 1" MANILA ROPE
CHART II - COMPARATIVE COST OF MANILA TRANSMISSION ROPE

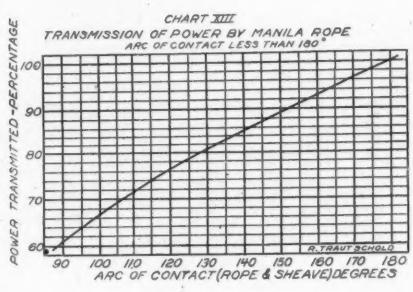


CHART III
TRANSMISSION OF POWER BY MANILA ROPE
ARC OF CONTACT LESS THAN 180°
POWER TRANSMITTED-PERCENTAGE
100 90 80 70 60
90 100 110 120 130 140 150 160 170 180
ARC OF CONTACT (ROPE & SHEAVE) DEGREES
R. TRAUT SCHOLD

PRACTICAL ENGINEER

TABLE 1. Piston Displacement Per Inch Stroke.

Dia. of Piston or Plunger in inches	Displacement in Gal., per in. Stroke	Dia. of Piston or Plunger in inches	Displacement in Gal., per in. Stroke
4	0.055	10	0.34
5	0.085	12	0.49
6	0.122	14	0.66
7	0.166	16	0.87
8	0.218	18	1.10
9	0.285	20	1.36

TABLE 2. Effect of "Slippage" on Pump Capacity.

Type of Pump	"Slippage" Factor
Deep well	0.88
Medium piston or plunger	0.85
Small piston or plunger	0.80
Large centrifugal	0.80
Medium centrifugal	0.60
Small centrifugal	0.40

TABLE 3. Pump Efficiencies.

Type of Pump	Average Mechanical Efficiency
Direct-acting steam	70 per cent.
Triplex power, 100 ft. head	60 "
Triplex power, 200 ft. head	70 "
Triplex power, 300 ft. head	80 "
Centrifugal	70 "
Deep well	50 "
Air-lift	40 "

TABLE 4. Steam Consumption of Pumps.

Type of Pump	Pounds of Steam per D. Hp. per hr.
Simple non-condensing	120
Compound non-condensing	65
Triple non-condensing	40
High duty non-condensing	30

PRACTICAL ENGINEER

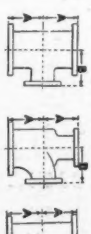
GENERAL DIMENSIONS—EXTRA HEAVY FLANGED FITTINGS—STRAIGHT SIZES
(All Dimensions are in Inches. Letters Refer to Cut Published in the Reference Tables for Oct. 15.)

Size	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15
AA	8	8½	9	10	11	12	13	14	15	16	17	18	20	21	23	26	30	31
A	4	4½	4½	5	5½	6	6½	7	8½	9	10	11½	12½	14	15½	19	21½	22½
B	4	4½	5	6	6½	7	7¾	8½	9	10½	11½	12½	14	15½	16½	19	21½	22½
C	5	5½	6½	7	7¾	8½	9	9½	10½	11½	12½	14	15½	16½	17	20	23	24
D	8½	9½	11	12	13	14	15½	16½	18	18½	21½	23½	25½	27½	29½	33½	37	39½
E	6½	7½	8½	9	10½	11	12½	13½	14½	15	17½	19	20½	22½	24	27	31	33½
F	2	2½	2½	2½	2½	3	3	3	3½	3½	4	4½	5	5	5½	6	6½	6½
G						6	6½	7	7	7½	8	9	10	11	12	14	16	17
H	4½	5	6	6½	7½	8½	9	10	10½	11	12½	14	15	16½	17½	20	23	24
I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
*K	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16	7/16
L	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	7/8	7/8	7/8	7/8	7/8
M	4	4	4	4	4	8	8	8	8	8	12	12	12	12	12	16	16	20
N	4	4	4	4	4	8	8	8	8	8	12	12	12	12	12	16	16	20

*Minimum Metal Thickness of Body.
L—Bolt circle.
M—Number of bolts.
N—Size of bolts.

PRACTICAL ENGINEER

STANDARD FLANGED FITTINGS
GENERAL DIMENSIONS REDUCING TEES AND CROSSES
(ALL DIMENSIONS ARE IN INCHES)



SHORT BODY PATTERN

Size	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15
*Size of Outlet and Smaller	All reducing fittings 1" to 9" inclusive have the same center to face dimensions as straight size fittings.																	
AA—Face to Face, Run											6	6	9	9	10	12	14	15
A-Center to Face, Run											18	20	22	23	24	26	28	28
B-Center to Face, Outlet											9½	11	13	13½	14	15½	17	18
Size	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76
Size of Outlet and Smaller	28	28	30	32	32	34	36	36	38	40	42	44	44	46	46	48	50	52
AA—Face to Face, Run	46	46	48	50	52	54	56	58	62	66	66	68	70	70	74	80	80	82
A-Center to Face, Run	28	28	28	29	29	31	33	33	35	35	37	39	40	41	42	44	45	46
B-Center to Face, Outlet	30	30	31	34	35	36	37	39	40	41	42	44	45	46	47	48	49	50

Size	16	18	20	22	24	26	28	30	32	34	36	38	40
*Size of Outlet and Smaller													
AA—Face to Face, Run	16	18	20	22	24	26	28	30	32	34	36	38	40
A-Center to Face, Run	30	32	32	34	36	36	38	40	40	42	44	44	44
B-Center to Face, Outlet	19	19	20	21	22	23	24	25	26	27	28	29	30
Size	78	80	82	84	86	88	90	92	94	96	98	100	
Size of Outlet and Smaller	54	56	58	60	62	64	64	66	66	68	68	70	
AA—Face to Face, Run	84	86	88	90	92	94	96	98	100	102	104	106	
A-Center to Face, Run	48	48	50	50	52	52	54	54	56	56	58	58	
B-Center to Face, Outlet	31	32	33	34	35	36	37	38	39	40	41	42	

*LONG BODY PATTERNS are used when outlets are larger than given in the above table, therefor have same dimensions as straight size fittings.

The dimensions of "Reducing Flanged Fittings" are always regulated by the reduction of the outlet. **REDUCING OR BULL HEADS**, the long body pattern will always be used except Double Sweep Tees, on which the reduced end is always one size smaller than the run. Long body fittings, will be the same length center to face of all openings as a tee with all the reduced openings of the size of the outlet, for example: a 12 x 12 x 18 inch tee will be governed by the dimensions of the 18 inch long body tee; namely 18½ inches center to face of all openings and 33 inches face to face.

BULL HEADS OR TEES having outlets larger than the run, will be governed by the dimensions of the 18 inch long body tee; namely

REDUCING ELBOWS, carry same center to face dimensions as regular elbows of largest straight size.

TABLE 5. Theoretical Horsepower for Compressing Air, for Air Lift Pumps.

Gage Pressure to which Air is Compressed.	Horsepower per cu. ft. of Air per minute. Single Stage.	Horsepower per cu. ft. of Air per minute. 2-Stage.
10	0.036	
20	0.063	
30	0.085	
40	0.104	
50	0.120	
60	0.134	
80		0.131
100		0.158
130		0.179
160		0.198
200		0.217

TABLE 6. Relative Air Volumes at Different Pressures for Air Lift Pumping Systems.

Gage Pressure.	Volume of Free Air Corresponding to 1 cu. ft. of Air at given Pressure.	Gage Pressure	Volume of Free Air Corresponding to 1 cu. ft. of Air at given Pressure.
10	1.68	110	8.48
20	2.36	120	9.17
30	3.04	130	9.84
40	3.72	140	10.52
50	4.40	150	11.20
60	5.08	160	11.88
70	5.76	170	12.56
80	6.44	180	13.24
90	7.12	190	13.92
100	7.80	200	14.60

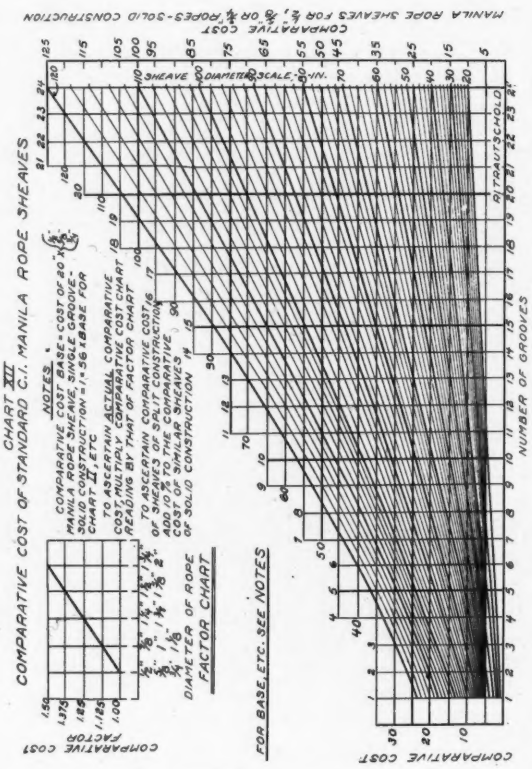


CHART XIII
COMPARATIVE COST OF STANDARD C.I. MANILA ROPE SHEAVES
MANILA ROPE SHEAVES FOR ½, ⅝ OR ¾ ROPES-SOLID CONSTRUCTION
COMPARATIVE COST
NOTES.
COMPARATIVE COST BASE = COST OF 20" MANILA ROPE SHEAVE WITH 6 GROOVES SOLID CONSTRUCTION = 1.36 BASE FOR CHART 14, ETC
TO ASCERTAIN ACTUAL COMPARATIVE COST, MULTIPLY COMPARATIVE COST CHART READING BY THAT OF FACTOR CHART
TO ASCERTAIN COMPARATIVE COST OF SPLIT CONSTRUCTION MULTIPLY THE COMPARATIVE COST OF SIMILAR SHEAVES OF SOLID CONSTRUCTION
DIAMETER OF ROPE
FACTOR CHART
FOR BASE, ETC. SEE NOTES
COMPARATIVE COST FACTOR
COMPARATIVE COST
NUMBER OF GROOVES
RITTAUT SCHOLD

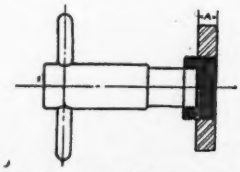
GENERAL DIMENSIONS—EXTRA HEAVY FLANGED FITTINGS—STRAIGHT SIZES

(All Dimensions are in Inches. Letters Refer to Cut Published in the Reference Tables for Oct. 15.)

Size	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
AA	33	36	39	41	45	48	52	55	58	61	65	68	71	74	78	81	84
A	16½	18	19½	20½	22½	24	26	27½	29	30½	32½	34	35½	37	39	40½	42
B	24	26½	29	31½	34	36½	39	41½	44	46½	49	51½	54	56½	59	61½	64
C	9½	10	10½	11	12	13	14	15	16	17	18	19	20	21	22	23	24
D	42	45½	49	53	57½												
E	34	37½	40½	43½	47½												
F	7½	8	8½	9½	10												
G	18	19	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
H	25½	28	30½	33	36	38½	40½	43	45½	47½	50	52½	54½	57	59½	61½	65
I	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53
*K	1¼	1⅜	1½	1⅝	1¾	1⅞	2	2⅛	2¼	2⅜	2½	2⅝	2¾	2⅞	3	3⅛	3¼
L	22½	24½	27	29½	32	34½	37	39½	41½	43½	46	48	50½	52½	55	57½	60¾
M	20	24	24	24	24	28	28	28	28	28	32	32	36	36	36	40	40
N	1¼	1¼	1⅜	1⅜	1½	1⅝	1⅝	1⅝	1⅞	1⅞	1⅞	1⅞	1⅞	1⅞	2	2	2

*Minimum Metal Thickness of Body.

L—Bolt circle.
M—Number of bolts.
N—Size of bolts.



APPLICATION OF BRIGGS PIPE THREAD GAGES

REMARKS:

The dimensions in table below are those of the dimension "A" shown in the above sketch, and are the figures adopted by the Manufacturers' Standardization Committee.

In the use of the plug gage, the notch on the plug is to gage, and one thread large or one thread small must be the inspection limits.

In the use of the ring gage, male threads are to gage when flush with small end of ring, and one thread large or one thread small must be inspection limits.

TABLE

Pipe Size	Adopted Thickness of Ring Gage "A"	Pipe Size	Adopted Thickness of Ring Gage "A"
⅛	.180	5	.937
¼	.200	6	.958
⅜	.240	7	1.000
½	.320	8	1.063
¾	.339	9	1.130
1	.400	10	1.210
1¼	.420	12	1.360
1½	.420	14	1.562
2	.436	15	1.687
2½	.682	16	1.812
3	.766	18	2.000
3½	.821	20	2.125
4	.844	22	2.250
4½	.875	24	2.375

This installation was made by the Lufkin Electric Light & Power Co., Lufkin, Texas. The pump is a Gould's triplex having a capacity of 350 gal. per minute, and is driven by a 2200-volt, 50-hp. Westinghouse motor. It operates against a head of about 130 lb. and is supplied with a relief valve so that it can be started against this pressure without injury.

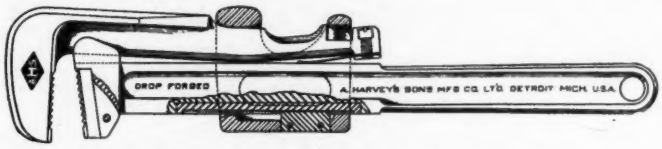
A One-Hand Pipe Wrench

THIS new Harvey's Wright pipe wrench, has been submitted to the tests, and meets the approval of the U. S. Naval Board of Constructors, and is now listed in their Index to Specifications covering "Tools and Materials Best Suited for Use in the U. S. Navy."

Also, the Harvey Co. furnished samples, for service trials, to several of the foremost mechanical authorities of the country, and the reports after months of daily use, were so strong that the company markets it under a strong money-back guarantee.

In this wrench there are practically but 3 working parts, the movable jaw and the frame, or yoke, of the new wrench having the rocking motion to give the "bite" and "release" action of a pipe wrench.

Springs are concealed from dirt and abuse and are not in action when wrench is under strain. The wrench is proof against any greater opening than the maximum provided for in each sized wrench. It is light and can be used with and instantly adjusted by one hand. A screw driver will disconnect and connect all working parts.



NEW HARVEY'S WRIGHT PIPE WRENCH

The wrench is at present made in 3 sizes, 9 in. with 1 in. pipe opening, and 14 and 18 in. with 2 in. pipe opening, although models are out for larger sizes up to 24 in.

Hardening and Dust-Proofing Floors

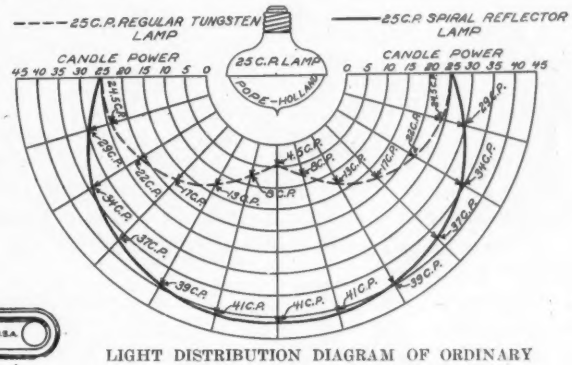
IN many places, it is desirable to have a floor which will withstand wear of heavy traffic, will be impervious to moisture, and yet will not be a source of dust from the wear of traffic. The problem has been a difficult one, and many materials and combinations have been tried.

In the Drake Bakery, Brooklyn, N. Y., concrete floors have been used, and have been treated in either of 2 ways. In the main entrance, in the hallway, the refrigerating room, the receiving room, and the wash room, the concrete floors have been finished with Smooth-On Cement No. 7, and in the oven room, the engine and boiler rooms, and the driveway leading to the ash chutes, the concrete has been hardened with the Smooth-On No. 7 in order to insure that it shall withstand the wear. It is found that this finish is oil and waterproof, that it resists the heavy traffic, and the bumping of heavy cases sent down the receiving chute, and that it, also, shows no deterioration under either the cold of the refrigerating room or the dropping of coals and hot ashes in the ash chute. It has, therefore, shown its usefulness over a large range of difficult conditions. For those who may be interested in the material, a booklet can be had from the manufacturers of Smooth-On, giving full directions for its use.

A New Lamp

A LAMP which will be in great demand in factories, machine shops, power plants, etc., or wherever a lamp may be subject to jars, vibrations or other hard handling, is the new Pope "Sunlite Reflector Lamp" recently placed upon the market by the Kinkhead Mfg. Co. of Boston, Mass.

Due to the use of spiral filaments and a porcelain reflector or shade, it is claimed by the distributors that



LIGHT DISTRIBUTION DIAGRAM OF ORDINARY TUNGSTEN AND "SUNLITE" LAMPS

in many cases this lamp can be used to give as great light efficiency as larger watt lamps of regular types with a 33 per cent saving in power. It is specially designed to distribute effectively and without waste the full lighting power of the lamp.

The accompanying diagram illustrates the most important features of the lamp. It shows the comparative distribution of light between a regular tungsten lamp with the up-and-down filament and the "Sunlite Reflector Lamp" with its spiral filament.

In each case, a lamp of 25 c.p. along the horizontal is assumed. The heavy dotted line shows the light curve of the ordinary tungsten lamp, while the heavy full line shows the light curve of the "Sunlite" lamp. It is seen that the ordinary tungsten lamp, as shown by the dotted line, gives its greatest efficiency on the horizontal line, decreasing to 4.5 c.p. directly under the lamp, while the "Sunlite" lamp measures 25 c.p. on the horizontal and 41 on the vertical.

This higher efficiency is said to be due to the arrangement of the filament, the shape of the bulb and the porcelain shade, all the result of scientific design and careful and exhaustive experiment.

Catalog Notes

HOMESTEAD VALVE Mfg. Co., Pittsburgh, Pa., recently issued a circular illustrating several varieties of Homestead valves.

SAVING FUEL, a new publication from Armstrong Cork Co., Pittsburgh, Pa., deals with the use of Nonpareil insulating brick in boiler settings.

SPRAGUE ELECTRIC WORKS, 527 West 34th St., New York, recently issued Bulletin No. 48,700, on the subject of Sprague electric monorail cranes.

Bulletin No. 48,701, superseding Bulletin No. 112, deals with Sprague electric dynamometers.

A NEW CIRCULAR from Smooth-On Mfg. Co., Jersey City, N. J., tells the difference between 2 grades of Smooth-On castings. The company will be pleased to send a copy of this circular to any person sending his name and address.

FROM THE Fuel Engineering Co., of New York City, which makes a specialty of analysis of fuels, preparation of specifications and test of deliveries, has been received a valuable and interesting leather-bound book entitled "Cost of Power." The price is given as $2.

Besides the arguments for placing the fuel problem in the hands of an expert company, which has numberless records, carefully indexed, and a trained force for making analyses of fuel, there is a simple and valuable discussion of the properties of coal, the effect of different impurities, and what full knowledge of the fuel supply means to the power plant in the way of increasing efficiency and decreasing expense. The book is worth careful reading by every man who buys and burns coal for power purposes.

CENTRAL STATION POWER in Coal Mines is the title of a pamphlet (3078), just issued by the Westinghouse Electric & Mfg. Co., dealing with the subject of electric power for coal mines and showing the advantages to be gained by the operator from using power from central station plants. A number of tables are given showing the cost of operation; curves are also given showing the day and night load in the mine.

Train Operation for City, Suburban and Interurban Service, No. 1546, is a collection of illustrations with brief notes showing the advantages to be derived from the use of multiple unit trains. This book is well illustrated with views of a number of properties in all parts of the country which make use of the multiple unit train equipped with Westinghouse apparatus. Among the interesting features are some curves showing the small amount of current required for a high-speed interurban car when handled in a careful manner.

Following its usual custom, the Westinghouse Co. has this year issued a Progress Leaflet No. 1552, in which is outlined the progress made by the company in electric apparatus. Among the items included are the Philadelphia Terminal electrification of the Pennsylvania Railroad; the electrification of the Norfolk & Western Railway Co. of the Bluefield Division in Virginia; the recent addition to the New York, New Haven & Hartford road and a large number of other steam railroad electrifications, and city surface, elevated and subway lines both at home and abroad.

PRACTICAL ENGINEER

Trade-mark, Reg. U. S. Pat. Off.

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About nine words make a line. Minimum space sold, two lines.

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Circulation of this issue, 23,500

Technical Publishing Co.
537 S. Dearborn Street
Chicago

Position Wanted

POSITION WANTED—By young man, 19 years old, as fireman or assistant engineer. Experience with steam, electrical and refrigeration machinery. Can start Jan. 1st. References. Clarence Pickett, Pultneyville, N. Y. 11-1-1

POSITION WANTED—As Manager or Superintendent of a steam plant of 600 kv.a. capacity or less, where efficiency and net earnings is the slogan. Twenty-one years' experience. A1 references. Will be released about Nov. 1st. Address Box 373, Practical Engineer, Chicago, Ill. 11-1-1

POSITION WANTED—As oiler in stationary plant by a man with five years' experience as stationary engineer; four years as oiler and three years as fireman. At present assistant engineer on lake steamer. Thoroughly familiar with boilers and their operation. Twenty-eight years of age, and can furnish best of references. Open for engagement Jan. 1, 1915. South Chicago preferred. Address J. A. DeLude, Marine City, R. F. D. No. 3, Mich. 11-15-1

POSITION WANTED—As chief engineer and electrician; 25 years' experience with steam and electrical equipments, and "Diesel Engines," accustomed to the economical management of power plants and their maintenance; erecting engineering experience; good all round mechanic and electrician; age 44, married, strictly sober; best of reference; correspondence solicited. Address Leonard Miller, 100 Greenleaf St., Brownwood, Texas. 11-15-1

POSITION WANTED—Contracting and consulting engineer's practical steam fitter desires work with a reliable firm. Can furnish skilled work from plans or take charge of job. Sober. Work and advancement desired. Only good position considered. Address Box 362, Practical Engineer, Chicago, Ill. 11-15-1

POSITION WANTED—By practical man to take charge of small electric light plant. Technical education and six years' experience. Can do any kind of interior wiring or line work. Reference from former employers. No use for liquor. Complete set of tools and indicator. A. W. Sailor, care of Wickblom Mfg. Co., Kewanee, Ill. 11-15-1

POSITION WANTED—As Chief Engineer of Ice or Ice and Electric Light Plant. Am married; 39 years old. Strictly sober. Can give best of references and can make good. Ten years' ice-making experience. Address Box 372, Practical Engineer, Chicago, Ill. 11-15-1

POSITION WANTED—Night Engineer in charge of 3000-hp. electrical plant consisting of Corliss engines, turbines and alternating current generators. Age 29. Married. Sober and steady. Seven years' best experience. Wants day work. Address Box 371, Practical Engineer, Chicago, Ill. 11-15-1

POSITION WANTED—By young man, age 23, as oiler or assistant engineer in power plant. Six years' experience with steam engines and boilers. Holds first class license for Minnesota. Small plant preferred in Minnesota, North Dakota or Iowa. Address E. U. Webster, Beltrami, Minn. 11-1-1

Wanted

AN OPPORTUNITY for High Class Salesmen. A well known, established concern, manufacturing power plant specialties, wants representatives in the following territories: Syracuse, N. Y.; Louisville, Ky.; Tacoma, Wash.; Birmingham, Ala.; Raleigh, N. C.; Nashville, Tenn.; Duluth, Minn.; Cincinnati, O.; Denver, Colo. Applicants must be able to show good selling record and possess a knowledge of boiler equipment. Excellent opportunity for high class men. Details of experience and references in first letter. Box 375, Practical Engineer, Chicago, Ill. tf.

FREE ENGINEERING BOOKS and power plant tools and specialties for securing new subscribers to Practical Engineer. A dandy chance for the engineer with a little spare time, to get some fine premiums. Send for free descriptive circular and terms. Address Practical Engineer, Subscription Department, Chicago, Ill. tf.

WANTED—Resident subscription agents in all cities of 50,000 population, and over. Many of the largest cities still open. An excellent chance for hustlers to turn their spare time into dollars. Practical Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

WANTED—Engineers who have trouble with poor circulation, foaming or priming boilers and accumulation of scale and sediment and leaky tubes to know of our sure remedy for these evils. Write for details to Olson Automatic Boiler Circulator Co., 217 Chamber of Commerce Bldg., Chicago, Ill. 10-1-6

WANTED—A few hustlers to take orders for Zinco Soot Destroyer. Quick sale. No competition. Good proposition. New York Supply Exchange, Ford Bldg., Detroit, Mich. tf.

WANTED—ALL STEAM USERS to have clean boilers without using compounds or chemicals in any form. Write "Otis," No. 317 Norfolk Ave., Buffalo, N. Y. tf.

Help Wanted

WANTED—Agents on commission to sell our Shaking Grates. We will install grates on trial or put in on test at our expense with any grate made. Address Armstrong Mfg. Company, Springfield, Ohio. tf.

For Sale

FOR SALE—24x36-in., 100 revolutions, 125-lb. automatic cutoff Conway engine, right hand, shaft 18 ft. 6in. long with two wheels 12 ft. 2 in. by 26-in. face and 11 ft. 10 in. by 20-in. face. In good condition and can be seen running any time before Nov. 1st. Built by Filer & Stowell Co., Milwaukee. Is as economical as a Corliss. Worcester Lumber Co., Ltd., Chassell, Mich. 11-1-4

FOR QUICK SALE—One 12x36 Atlas Corliss over-runner engine and one Atlas boiler, 14x5 with 3½-in. flues; both engine and boiler are in fine shape, and we will sell them cheap if sold at once, as we are changing our power from steam to electric. The Bloomington Milling Co., Bloomington, Ind. 11-15-2

TWO TABOR INDICATORS, U. S. Navy standard, outside springs, Houghtaling reducing motions, completely equipped, in cases, brand new, for price of one. John Astrom, Fort Wayne, Ind. 11-15-1

FOR SALE—Gebhardt Steam Flow Meter, new, with following sized pitot tubes: 2, 2½, 3, 4, 5, 6, 8, and 12 in. Cost $135. Will take $120. P. A. Johnson, Springfield, O. 11-15-1

FOR SALE 20x42 Vilter Corliss engine, perfect condition, $600; 28x48 Hamilton Corliss engine, excellent condition, $975. Duzets & Son, Hudson Terminal, New York. tf.

FOR SALE—12x30 Cooper Corliss engine. Nappanee Lumber & Mfg. Co., Nappanee, Ind. 11-15-2

Patents and Patent Attorneys

PATENTS—Send sketch for free search and report. Books on patents and book of reference letters sent free. John S. Duffie & Co., 612 F St., Washington, D. C. tf.

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. 186 McGill Bldg., Washington, D. C. tf.

PATENTS THAT PROTECT AND PAY. Advice and books free. Highest references. Best results. Promptness assured. Send sketch or model for free search. Watson E. Coleman, Patent Lawyer, 624 F St., Washington, D. C. tf.

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had, and the exact costs. Send for full information. tf.

"PATENT YOUR INVENTIONS."—Search free when patent applied for. Charles F. Kincheloe, Patent Lawyer, Woodward Building, Washington, D. C. 10-15-6

PATENTABLE IDEAS WANTED—Send for three free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. tf.

Educational and Instruction

ENGINEERS' POCKET MANUAL, 175 pages, edited by University of Tennessee, will be mailed every subscriber sending in NEW subscription (not your own) to Practical Engineer. Gilt edges; bound in leather.

Miscellaneous

ENGINEERS DO YOU WANT to utilize your exhaust steam for heating or drying purposes, without back pressure on your engine? If so, address Monash Engineering Co., 1413 W. Jackson Blvd., Chicago, Ill. tf.

Sparks From The Advertising Pages

The Mayor of New York needed a man for an executive position in a city department. Instead of choosing a politician he inserted a blind want ad in the New York newspapers. Out of scores of applicants he selected the man.

The want ad as a medium of connecting trained men with good positions is growing in favor. You will recall that only a few weeks ago we told how the man who engineered the building of the Keokuk dam was secured through the want ad columns.

The war brings home one point in favor of advertised goods. All advances in price have been on non-advertised products. Do you know of a single advertised product that has raised its price?

A further contribution on the effect of advertising on the cost of the product is the following from the *Merchant and Manufacturer:*—

> That advertising reduces the cost of merchandise to the maker and to the consumer is proved by the fact that advertised goods are invariably cheaper than unadvertised goods of the same quality. For example, a fortune is spent every year advertising Ivory Soap, yet Ivory Soap is the cheapest soap of its class sold.
>
> If advertising *increased* the *cost* of production, the half million dollars spent yearly advertising Ivory Soap would necessarily appear in the *increased cost* of the soap, but the result is that advertising so increases the sales volume and facilitates the distribution of Ivory Soap by making its qualities and merits so well known, creating a desire in the consumer to want it and nothing else, teaching the consumer to get it easily, that this immense sum of money is absorbed in the enormous increased volume of business which advertising creates, and causes the elimination of countless transactions and sale expenses necessary in the distribution of unadvertised goods.
>
> This proof is as positive in a hundred other articles, clothes, food products, furniture and household goods.
>
> Advertising reduces the cost of merchandise to the manufacturer and the consumer.

A letter from William Jones, 40 Locke St., Ansonia, Conn., closes:

"I have gotten a great good from the reading of articles and many good things from its advertising pages. I always look over the whole paper with profit. I have been engineer and fireman 40 years and in the present position going on 33 years."

If a man with Mr. Jones' experience can find value in the advertising pages of *Practical Engineer;* there is not much room left for argument about their value.